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NATIONAL ECONOMY IN ENGLAND [See page 136]

Modern Aeronautics—I*

A Review of Some Outstanding Problems

By Dr. W. F. Durand

TEN years ago the aeroplane was a curiosity—a means wherewith, by a tour de force, a man might lift himself from the ground and make a hazardous flight through quiet air—a means to attract curious crowds to fenced-in county fair grounds to witness the marvel of a body heavier than air actually rising from the ground and moving under some measure of control through the air, and returning safely to its starting point.

What the aeroplane has become in this short but poignant decade of the world's history, and what it stands for today, this audience knows too well to need specification in detail.

It is perhaps well within the limits of conservatism to say that no achievement of man's inventive and constructive genius has undergone more intensive, more rapid, or more potentially significant development than has that of flying with an apparatus heavier than the air in which it moves.

It may be further noted that perhaps no technical and constructive achievement of man has ever called more largely on science and on the aid of scientific research to aid in the solution of the many problems which have presented themselves in the course of this astonishing development in aerial navigation which the past decade has witnessed.

Under the circumstances which have determined the direction and character of the development of the aeroplane during this decade, and especially under those which have been controlling during the past three or four years, it is only to be expected that at the present moment we should find ourselves with many partly solved problems on our hands, with others which we have hardly more than begun to attack on the outskirts and confronted by others still, the character and significance of which we have hardly begun as yet to apprehend.

On the present occasion we may find it not without interest to pass briefly in review some of these problems, noting their present status together with such indications as may in some cases serve to point the way toward a possible solution.

THE PROBLEM OF CONSTRUCTIVE MATERIALS

Perhaps nowhere is there to be found a better illustration of the inter-dependence of technical and scientific research and study than in the manifold advances in various technical and scientific lines which conjointly have made the aeroplane in its present form a structural possibility.

Broadly, the modern aeroplane comprises a body of some sort or form fitted with wings to provide the supporting surfaces, with a prime mover or source of power and with a propeller of some type to transform the power provided by the prime mover into propulsive work, and by the reaction of the relative air stream on the under side of the wings, to secure the sustaining or lifting force necessary to carry the weight. This construction calls for a wide range of constructive materials. Thus the body and wings, comprising the aeroplane proper, require the following fairly distinct classes of structural elements:

(1) Those intended primarily to give form, strength and coherence to the structure. They represent in effect the skeleton or foundation on which the entire function of the aeroplane as such must depend.

(2) Various secondary elements intended to so tie or connect the principal members together as to secure homogeneity of structure as a whole, and mutually responsive action on the part of the different elements comprised under No. 1. The elements here considered are those which, from a purely structural viewpoint, may be classed as struts and ties or tension members, with suitable connections and joint fastenings.

(3) Surface covering for the body and wings. This gives outer form and continuity of surface and provides furthermore the actual surfaces on which the air lifting and supporting forces may act.

Broadly speaking, the fundamental problem in all aeroplane construction is adequate strength or function on minimum weight. In no other form of engineering construction is the necessity for weight saving so rigorous. In a very real sense every ounce of material entering into the structure must be able to show a competent passport. The structural problem of the aeroplane is therefore one of strength in relation to weight. For the main elements comprising the skeleton of the structure, wood has, thus far, held the main place with metal construction steadily attracting more and more interest and assuming a place of growing importance, at least in the study of new designs.

It is not necessary to our present purpose that we should consider in detail present practice in aeroplane construction. The trend of development since the earliest days of the art has tended to show that wood construction under suitable design and safeguard was able to provide the easiest and on the whole the most satisfactory solution of the many problems and requirements which aeroplane construction presents, and so we have been content, for the most part, with this type of construction.

We may, however, be well assured that no matter how good may be any solution which we may reach of the many problems presented to us in the industrial arts, there are, as a matter of fact, series of better ones only awaiting our patient study. This is indeed a fundamental truth of which we should never lose sight. We may be, for the moment, satisfied with out solution of a problem in technical industry; we may be able to see nothing better, and yet we may be well assured that, as a simple matter of fact, there is something better. This is a perfectly safe assertion, if only as based on the law of probability of our having, at any given time, reached the final optimum possible combination capable of furnishing a solution of the problem.

Thus, as applied to the problem of constructing the framework of the fuselage of an aeroplane or of combining together wing spars and ribs in such manner as to form a wing skeleton, we may be sure, however satisfactory our present practice may seem and however good it may really be, that in reality it is not the best and that long series of better solutions only await our intelligent and patient study.

In this and in all such problems there are always two fairly distinct though inter-related parts.

(a) What materials are best suited to the purpose in view.

(b) What disposition shall be made of the materials adopted.

Thus, in the case of the fuselage, granting wood material to be adopted, there remains the question as to the very best distribution of such material as between the main longitudinal elements, or longerons, and the intermediate elements; also as to the extent to which reliance may be placed on the outer covering, especially if of ply-wood. What aeroplane designer can feel sure that, even with given materials, he has reached the optimum distribution of function as between the main and secondary elements of the fuselage and of a ply-wood outer covering?

Much less, what aeroplane designer can feel any confidence in having now reached an optimum combination, once we admit the possibility of metal construction, or of some combination of metal and wood, with all the possibilities of the new light metal alloys and of the new alloy steels with their astonishing physical characteristics.

So far as conditioned by the application of the ordinary loading tests, static in character, and aside from the possible results of dynamic attack, shock, long continued vibration, etc., we may perhaps frankly admit that the present state of metallurgy is able to supply us with material, either in the way of light aluminium alloys or special steel alloys, which if properly used, will enable us to meet all such static tests in an aeroplane construction, and on even terms or better as regards weight compared with wood.

If such is the case, it certainly stands before us as a problem for the near future to pass in review most thoroughly the entire range of constructive materials, metallic as well as wood, and to determine, in the light of the experience which we are so rapidly accumulating during these days of storm and stress in military aeronautics, the combinations of materials which may assure the most efficient service on the minimum of weight.

In connection with this search for new and better materials, must go hand in hand, search for better modes of combination in the structure—in other words, better structural design. It goes without saying that the best general type of design, in the way of the distribution of materials, forms and proportions of members, etc., will vary with the class of material employed. There must be some optimum design with wood. There will likewise be another and undoubtedly a different optimum design in the case of steel, and again different in the case of aluminium or other alloys. Thus the search for the best final combination is a search for an *optimum optimorum*, for the best possible material and for the best possible design using such material.

What order of saving may be looked for in the near future from any such search it is, of course, idle to predict. Could we however approach somewhat closely to the best use of the best combination of materials even now available in the field of engineering construction and without waiting for new and superior materials which the metallurgical art will doubtless be able to furnish, it seems not unreasonable to anticipate the possibility of a marked saving in weight without loss in strength or security.

This then stands out as one of the great problems of aeronautic engineering, that of the best materials and of their best use. Much has already been done, but much yet remains, and rich rewards most assuredly await patient and well directed work in this field.

THE PROBLEM OF SIZE

One of the most interesting of the problems presented to the aeronautic engineer is that of the limiting size and carrying capacity of aeroplanes. Is there such a limit? If so, what is it? Why is it? And how may it be removed or extended?

In dealing with this problem we come, of necessity, into contact with the laws of similitude of geometrically similar structures. It is well known that under simple modes of loading, geometrically similar structures of wing and fuselage will have similar factors of safety under equal unit loads. But for such structures, if strictly similar geometrically, the weights themselves will increase as the cubes of the similar dimensions, while the areas of wing or supporting surface will only increase as the square, and hence the ratio of weight to area will continuously increase as the linear dimensions.

Under these circumstances, it is readily shown that, in accordance with the relation of the factors involved, there will be, for any given speed, some size for which the lifting capacity over and above the structure itself will be a maximum and above which the lifting capacity over and above the structure will become less and less with increase in size, gradually reaching zero for some value of the size of the structure. This would mean that at such point the supporting force developed at the speed in question would be just enough to lift the structure itself from the ground, but with no reserve for additional load.

This is, of course, a definite law derived from well known principles of geometry and calculus, and if it were the whole story, it would indeed tend to raise an insuperable bar before continued expansion in size. If such were the case it would mean in effect that increase in lifting capacity could only be reached by the following measures:

(1) Reducing to a minimum the relation of weight of structure to area. That is, general improvement in the program of design and reduction of weight of structure in relation to supporting surface.

(2) Reducing to a minimum the resistance of the plane at the given speed and likewise the relation of weight to horse-power.

(3) Raising to a maximum the relation of lifting force to area, consistent however with the decrease of the total propulsive resistance of the plane.

Were we indeed subject, without recourse, to the operation of this law of mechanics and geometry we should be in a sorry state regarding the future development of the aeroplane as regards size and carrying capacity. We should be limited strictly within the bounds of the developments made possible by improvements and advances along the lines as indicated above. But fortunately for the future of aerial navigation, we are not so limited and there seems no reason why, at the present time at least, we should need to anticipate any especial limit as necessarily imposed on aeroplane construction, as regards either size or carrying capacity.

We are able to escape from the consequences of this law by reason of two facts.

(1) It is not necessary that a large element of an aeroplane, a wing in particular, should be geometrically similar in structural characteristics to a small one. For a certain size the structural elements will partake of certain characteristics. As the overall size increases, these elements may take on new characteristics. Those which had been solid may now become hollow or of lattice or built-up form. The law of geometrical similitude will not hold and the weight will not necessarily

*From the *Aeronautical Journal*.

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increase in ratio with the cube of the overall linear dimensions.

(2) It is by no means necessary that a large aeroplane shall be, in its general form, a geometrical copy of a small one. While both will have similar elements, such elements need not be the same in number or arrangement. In fact one of the most obvious of means for increasing lifting power is to increase the number of the wings or lifting elements. There is no reason, at least structurally, why wings and connecting elements should not be increased in number beyond anything now in use or even considered—increased to a point which would give a size and lifting power great enough to meet any demands which we can now formulate or which the future seems likely to present.

Structurally, therefore, the problem of increased size presents three problems as follows:

(1) The structural problem of so developing the character of the elements of aeroplane construction such as wing spars, longerons, struts, ribs, etc., that with increase in overall dimension the weight shall not increase sensibly faster than as the square of such dimension.

(2) The structural problem of combining the larger elements of aeroplane construction such as wings, fuselage, or engine nacelles with their connecting structures, in such manner as to secure, for a given wing area, the minimum weight of secondary structure.

(3) The aerodynamic problem of combining multiple wing elements in such manner as to reduce to a minimum the interference of one with another. This is a problem which opens fascinating possibilities to the student of experimental aerodynamics—a problem on which already some beginnings have been made, but one far from a final or as yet wholly satisfactory solution, and one on which the future developments of greatly increased size and carrying capacity seems destined largely to depend.

In short, so far as increase in size is concerned, there seems no reason to apprehend any particular limit, or any serious difficulty on the part of the scientist and the engineer in meeting the demands of the future in these respects. The difficulties seem no greater than those which have been overcome in the case of ocean shipping as shown by the continuous development from the early beginnings of the application of engine power to ocean navigation during the first half of the last century down to the mammoth floating structures of the present time; and if we may take any indication from the accelerated rate of progress which has characterized the entire history of aerial navigation, we may feel confident that we shall not have to wait a half or three-quarters of a century for a parallel development in the latter field.

VARIABLE WING AREA OR VARIABLE WING CAMBER

To mention only one of the many remaining problems which are connected with the design and construction of the aeroplane itself, a word may be said with regard to the problem of variable wing area. Broadly speaking, the ideal aeroplane should be able to change its wing area in accordance with the conditions and circumstances of flight. For ease in getting off the ground at a moderate speed, for ease in landing likewise at a moderate or low speed, there is need of a relatively large area of wing or supporting surface. For the attainment of high speed, reduced wing areas are needed, and are furthermore sufficient for the support of the weight at such high speeds. The supporting force gained by a given form of aeroplane wing depends on the area, the speed and the angle of attack and there will be some combination best for each set of conditions. To meet these conditions, varying from time to time throughout the course of a flight, a correlative variation in wing area is needed.

To the same extent the same ends may be met by changing the camber or curvature and form of the fore and aft section of the wing.

Thus, when the camber or fore and aft curvature is increased, the form will be more suitable for landing at a reduced speed, while with curve flattened and camber reduced, the form will more readily favor the attainment of relatively high speed.

The problem of an adjustable wing, either as to extent of area or camber or both, is a favorite one with students of aeronautics and we may hope for some measure of useful and practical solution. Thus far, of the many devices and forms proposed, none has so far fully justified itself as an altogether satisfactory and practical solution of the problem.

MOTIVE POWER

Passing now to the motive power and its application to the propulsion of the aeroplane, a most interesting and important series of problems challenges our attention. Only the more important can be noted here.

Fuel.—One of the most important of these is that of fuel. What is to be the future fuel for the aeroplane, or for aerial navigation in its wider aspects? How long will our stores of crude petroleum oil from which we now obtain our petrol or essence or gasoline, as it is variously termed, continue to furnish this all-important element in the present program of power development? Doubtless there are large stores of petroleum oils yet undiscovered but we may safely assume that we are using up a supply in the nature of a bank deposit. We are using our principal and not living on the interest. So far as we know, nature is not now engaged in making for us petroleum oils, certainly not in any proportion to our rate of expenditure. To such a general program of consumption, there is, of course, but one end, ultimate exhaustion. This is, of course, only one phase of the overshadowing menace which the modern social and industrial world must face some time when our present supply of carbon and hydrocarbon fuels begins to become exhausted, unless indeed we develop or discover in the meantime some other source of energy which will adequately take their place. This is perhaps a question which need not seriously concern the present generation, but when we take a long look ahead—a look for example as long as that covered by the development of Europe from the days of the Cæsars or even from the time of, say, Galileo—we may realize with startling emphasis the need of foresight with regard to a source of energy adequate to the world's demands. Various ages have been designated as of stone, bronze, etc. The present might well be designated as that of natural energy. Our entire civilization, in a material sense, rests upon the utilization of sources of natural energy which are not inexhaustible and which are, in fact, becoming exhausted, in some cases, with menacing rapidity. In the meantime we must, and presumably we shall make some shift to tap efficiently other sources now known, or we may happily discover sources which today lie beyond our present vision.

A long look ahead for aerial navigation therefore shows that if the present line of development is to continue, there will be a serious problem to be met sometime, and that perhaps before many decades—the problem of a fuel suited to the needs of aeronautic prime movers, at a time when present petroleum sources will no longer yield the supply which we now accept and use with so little thought for the morrow.

But with regard to the question of fuels, we need not go so far afield as to look into the coming decades for interesting and important problems. Perhaps the one most pressing for present solution is the question of what is the best fuel for the modern aviation engine, having in view the three requirements—power, economy, with reliability and durability. Out of the exigencies of the present war have come many serious and extended researches relating to the problems of military aviation, and of these none is perhaps of greater significance regarding the future of commercial aviation than the studies which have been made regarding aviation fuels. While matters relating to the problems of military aeronautics must be spoken of with much reserve, it will perhaps be permissible to say before this audience that from these studies three principal results seem to have been rather definitely established. These are:

(a) As between the various grades of aviation motor fuels which have been used during recent years, and comprising a rather wide range of composition and of physical and technical characteristics, there is but little to choose from the standpoint of power or economy alone. This assumes, of course, that the fuel is a genuine motor fuel and the results regarding power or economy relate to a period of effective operation under such fuel. It must not, however, be assumed that there are no differences in power or economy traceable to the fuel employed, for such is far from being the case. It is however, within the limits of reasonable statement to say that such differences are relatively small and under most circumstances would not, of themselves, constitute a determining or controlling factor.

(b) As between such motor fuels marked differences do seem to be indicated as regards their influence on the life and reliability of the motor, especially on long time tests, or in actual service on long time flights.

(c) For the various fuels, in order to realize the best results either as regards power, economy, or life and reliability, special and individual carburator adjustments are necessary, and such as can only be determined by trial under actual working conditions.

It may perhaps be further said that the problem of an excellent and reliable motor fuel for aviation purposes seems to have been satisfactorily solved. Its specifications and range of characteristics, physical and chemical, are pretty well established, and so long as our source of motor fuel supply is to be found in petroleum derivatives, we seem to have reached a reasonably satisfactory determination of the best combinations of such derivatives for the various requirements of aviation service. These characteristics, which must be considered as a part of the great body of military information and which cannot for the moment be put down in plain print, we may hope will, in due time, become available in the arts of peace and for the development of commercial aviation in its various fields of promise.

The Engine.—With the problem of fuel, that of the prime mover or engine is closely related. Is the present type of engine to continue, or is it only a passing stage on the way to some more perfect form? This is a question, interesting indeed for speculation, but hardly to be considered in comparison with actual present moment problems. The present engine and its application to the propulsion of the aeroplane does, furthermore, present no lack of interesting and important problems, and among these a few of the more pressing may be here noted.

First, the problem of gross power. How much power can we put in an aeroplane or airship of no matter what type or form? This divides immediately into three subsidiary problems as follows:

(1) How much power from a single cylinder?

(2) How many cylinders for a single engine?

(3) How many engines for a single airship?

In the way of power per cylinder we are now reaching close about 40 h.p. as a maximum.

In the way of cylinders per engine we have reached a stage of development where the 12-cylinder engine is quite a standard type and higher numbers such as 16 and 18 represent only questions of detail. It is not too much to say that the 600 h.p. engine is quite within the reach of present practice and may be realized as called for. We have long since become accustomed to two and three engines on a single plane and are now seeing four engines in various recent designs. It is therefore clear that if a power plant of 2,500 h.p. on a single structure is wanted, it is quite within the scope of present practice to realize and provide such a plant; and if four engines of 500 or 660 h.p. each, there is no reason why the number may not be increased, at least to a point beyond the present apparent need for power on a single structure.

On the other hand, it must be admitted that, having in view the limitations of present practice, the most simple and in fact the only reliable way of extending power is by a multiplication of the number of cylinders rather than by an increase in the size of the latter. The fact that a 2,000 h.p. equipment would presumably require from 40 to 60 cylinders shows the formidable degree of multiplication of small elements required to realize such a result. The real problem of size or capacity of engine is therefore one of power in a single cylinder. What can be expected in this direction, and in what way shall search be directed?

The present limitation arises largely as a matter of cooling and it is in this direction that search may well be made for ways and means of effectively increasing the power capacity of a single cylinder in an engine of the aviation type. This is a problem which is distinctly outstanding and well worth our serious attention and study.

[TO BE CONTINUED]

Origin of the Nonius

AN article on the nonius, its origin, theory, and use by Senhor A. R. Machado, has been published in the *Revista de Quimica pura e aplicada* (Oporto II. Sér, Ano iii, 1918). Being a countryman of Pedro Nunez, the author calls a vernier a nonius, and proceeds to trace the history of this instrument from the book, "De crepusculis," by Nunez, published in 1542. In reality, there is no resemblance between the contrivance of Nunez and that of Vernier, published in 1631. Nunez proposed inside the graduated arc of a quadrant to draw concentric arcs and to divide them respectively into 89, 88, 87 . . . 45 equal parts, so that the alidade would always (more or less accurately) touch a division-mark on one of the forty-six circles. Though ingenious, the proposal was anything but a practical one on account of the difficulty of dividing a quadrant into eighty-three or sixty-seven parts. It was improved, though not made much more practical, fifty years later by Curtius, whose idea was published by Clavius. There is nothing new in all this; see, for example, Delambre's "Histoire de Pastronomie moderne," i., p. 253, or Cantor's "Geschichte der Mathematik," ii, p. 580. But no one put a small auxiliary arc on the movable alidade before Vernier. The author of the paper next describes the various uses of the vernier, including Mannheim's double one (vernier de vernier), proposed in the *Journal de Physique*, 1873, to meet the case where none of the divisions of a vernier coincide exactly with a division on the principal scale.—*Nature*.

The Aurora

Is It Possible to Explain It by Means of a Copuscular Ray Theory?

By Otto Stuhlmann, Jr., M.A., Ph.D.

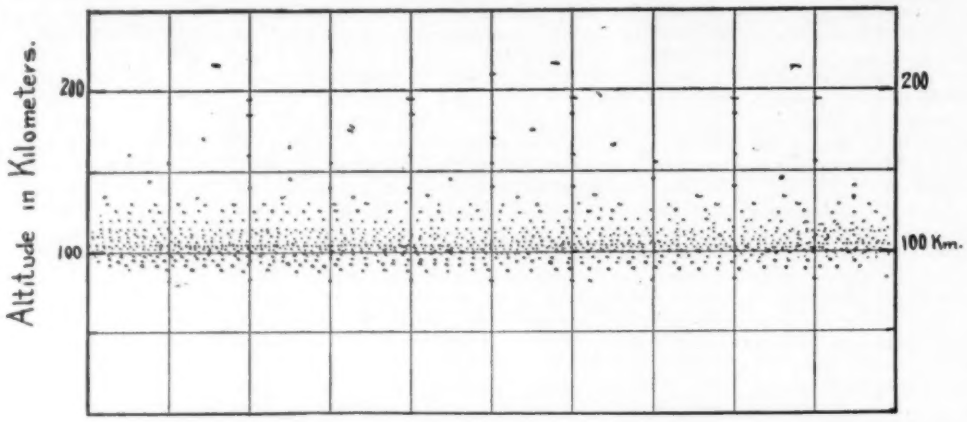
We hear from over seas that the Germans raided London during the aurora display on March 7th; making use of the unusual illumination to guide them that night over the usually stygian darkness enveloping that city. Probably few of the phenomena of nature so entirely charm and interest scientific and non-scientific men alike as the aurora borealis or "Northern Lights" as they are sometimes called. The spectacle seen on the night of the above date was one of unsurpassing interest and beauty.

Just a few minutes before seven-thirty, on the above date, in a latitude just north of Chicago there appeared one of the most beautiful and inspiring displays of "Northern Lights" that has been my good fortune to observe. It began like the dawn of a cold clear wintry morning. Faintly at first like pink mists of twilight it glowed in the northwest, followed by a similar glow toward the south and east. Soon a soft crimson glow tinged the heavens like the blush of dawn creeping over the sky. Rapidly white shafts of light shot across the zenith enveloped in faint phosphorescent patches of deathly green. The colors come and go and change from red to deeper red and shimmer as they wane. The bark of a dog out of the cold distant quiet night calls to my attention the fleeting minutes. The hour is nine. Simultaneously there appear toward the West and East and North three red wings of light like the splash of wet red paint smeared on the sky-line, to show how Nature in her more eccentric moods can outdo her bravest sunsets. And through it all and for half an hour more a death-like stillness reigns. Then suddenly through the haze that has settled on the far horizon, a green-white streak appears, followed rapidly by shafts as sharp and regular as two-edged swords, they leap higher and higher, they reach the zenith and lo and behold, a similar sheath of blades have climed the vault of the heavens from the other side; they meet and whirl in what appears a maelstrom overhead. The colors flicker, fret and flash like summer lightning through the sky. Through it all the stars shine as if the aurora had added extra luster to their silvery light. Soon all is motionless and calm, the time is ten-fifteen. Some purple reddish clouds fringed with the sheerest gauze-like drapery float across the scene. The shafts of light soon flicker, shrink and fade. A last slowly moving mass of phosphorescent haze fades from the vaulted sky; soon all has sunk into the depths of night.

Such a spectacle cannot fail at all times to be a subject of admiration, even to the least impressionable of men. Hence it is no wonder that the aurora has at all times received a considerable amount of attention at the hands of governments, learned societies and scientific men.

The most recent attention given to the solution of the cause of the aurora has been a paper by Carl Stomer (Kristiania). The conclusions drawn from his experiences and observations on the Aurora Borealis Expedition to Bossekop in the northern part of Norway, was published in the magazine for Terrestial Magnetism and Atmospheric Electricity in September and March of last year. His mathematical contribution explaining the well known experiments of Birkeland, will no doubt become classic. He made no less than 2,500 observations alone on the altitude the aurora reaches in the heavens. These altitude observations, which measure the height to which auroras ascend, are reproduced here in Fig. 1. From this diagramatic distribution and subsequent supporting data Stormer draws the conclusions that, "There are two predominant maxima, one at a height of about 101 to 103 Km. and the other at about 105 to 108 Km." That is, on the average the auroral display, as usually seen, takes place in the atmosphere about 65 miles above the earth's surface. The most natural question to ask is, Does the earth's atmosphere extend that far out? The height of the earth's atmosphere is usually conservatively placed at about 40 miles. There is abundant evidence from the phenomena of meteors that the atmosphere extends to a height of 100 miles at least, yet it cannot be asserted positively that it has a definite upper limit. Even at the height of 65 miles we are evidently dealing with phenomena taking place in a highly rarefied atmosphere, comparable to the pressure used in the electric vacuum lamp.

Some earlier observations taken at the Haldde Observatory, Norway, by L. Vegard and O. Krogness find



Altitude and Situation of Auroras.

Fig. I

the upper altitude limit to vary from 110 Km. to 330 Km. The very low limits were found belonging to the phenomena simulating arcs and draperies. The highest values were always found for the ray forms. To appreciate these observations, one must remember that, whatever is the explanation of the phenomena, the cause

Fig. II

seems to come from without and drive itself down into the denser regions of the air.

In treating these observations special attention has been paid to an exact determination of the bottom edge of the aurora, so as to find with the greatest possible accuracy the height to which the "cosmic rays" can

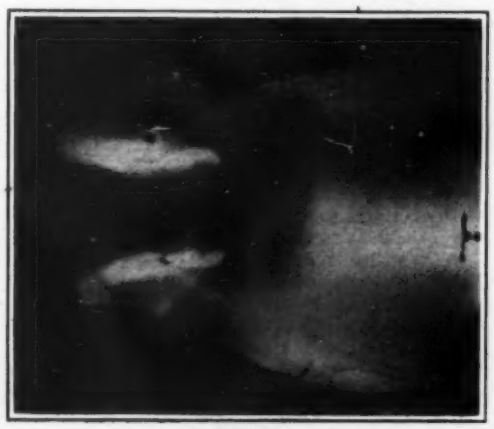


Fig. III

penetrate down into our atmosphere. This lower limit is also generally very sharply defined, while upwards the luminosity more gradually fades away into space, and the upper limit is consequently not so definite.

A subsequent series of 2,487 determinations of the height of different aurora included the following types: diffuse arcs, drapery shaped arcs, typical draperies, split bands, rays and diffuse pulsating light areas. On the average the results so far indicate that the forms enumerated are of the same nature. The fact that the rays do not descend so low as arcs and draperies is somewhat striking and contrary to the impression one gets from a direct examination of an auroral display.

As pointed out by Stormer these observations also agree well with his recent results. The existence of maximum altitudes attained by the display, which seem to remain unaltered from one year to another, is a fact of far reaching importance. The immediate conclusions one can draw from this is that "a predominant part of the cosmic rays, coming presumably from the Sun and producing the aurora-borealis, is made up of two groups, each of which has its own quite definite penetrating power. The fact that the diffuse arcs, the drapery-shaped arcs, and the draperies all give the same principle maxima affords evidence that these most frequent forms are essentially of the same physical nature and must be produced by the same kind of rays." Of the less frequent forms not sufficient data is on hand to warrant any certain conclusions; though the small differences in the average height of the aurora indicate "that all forms are produced by the same type of rays."

Now what are these "cosmic rays" here referred to? This question has in the past years drawn into this interesting field of research such eminent men as Poincare, Birkeland, Arrhenius, Lenard and others, who have attempted to explain the phenomena both from an experimental as well as mathematical point of view, using some form of electron (corpuscular) theory as a basis.

It appears, however, that the physicist Goldstein[1] was the first to publish the idea that the sun sends out into space electrical rays analogous to cathode rays, and that we may thus explain the mysterious connection between variations in solar activity and the corresponding fluctuations in the magnetic and electrical phenomena on the earth.

Some years later (1894), the Danish meteorologist, Adam Paulsen, was led to the hypothesis that the aurora is due to cathode rays; but instead of assuming that the rays come from the sun he believed that they originated in the upper strata of the atmosphere. In 1896, however, Kr. Birkeland made some far-reaching and remarkable experiments with cathode rays in a magnetic field. Perhaps they were suggested to him through some observations during his Norwegian Aurora Polaris Expedition of 1902-1903.[2] In his journal he remarks that "we had made a very interesting observation of a rare, but very significant, auroral phenomenon. It was ten minutes to six on the evening of the fifth of February, when we were some miles from Hammerfest, the weather clear and the moon shining, when there appeared a sharply defined arc of light from east to west through the zenith. From the first the arc was very intense but very narrow, right above our heads. Notwithstanding the bright moonlight the aurora, which soon began to pass through various phases of development, with draperies and sheaths of rays, was visible up to half past seven when it disappeared . . . It immediately occurred to me that the observation was a confirmation of the hypothesis put forward by me in 1896 regarding the origin of the aurora, namely, that the "Northern Lights" are due to cathode rays or similar rays emitted by the sun, these rays being drawn from space toward the earth by the terrestrial magnetic forces."

On returning from this expedition he attempted to reproduce the aurora effect in the laboratory on the

[1] Goldstein. Wiedemann Annalen, vol. XII., p. 266, 1881.
[2] Published by Longmans, Green & Co.

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hypothesis that cathode rays converge upon the earth's poles from without the atmosphere. With what brilliant success these experiments were performed can be seen from the accompanying photographs (Figs. II, III and IV).

He first found that a magnet had an effect on a beam of parallel moving cathode rays (swiftly moving luminous, negative electric charges that pass through a vacuum when an electric potential is applied to oppositely placed metal terminals). The result was analogous to that of a lens upon a beam of light, the magnet, when used as the terminal upon which the rays were to impinge, forced them to converge toward a point upon its surface. This simple experiment showed him that the aurora borealis might be due to a similar effect, viz., the effect of the earth's magnetic field on the hypothecated rays coming from the sun. In order to test his theory further he exposed a spherical electromagnet to a stream of cathode rays coming from one side of a large vacuum chamber. Fig. II shows this electromagnet in the form of a spherical shell which simulates the earth in the following experiments. This spherical magnet was 36 centimeters in diameter, could be magnetized so as to conform to the magnetic figure of the earth, with magnetic poles at opposite ends of the diameter of this iron sphere. This was placed into a large glass vacuum chamber of 1,000 liters capacity. Its sides were made of heavy plate glass. In one corner of this huge rectangular vacuum chamber was placed an aluminium cathode, while the metallic parts of the box acted as anode when an electric discharge was passed through it. Imagine yourself standing on the sphere, shown in Fig. II, looking upward, and it becomes apparent at once that it strikingly simulates the aurora rays, striking downward all around, forming the auroral zones of the earth. The arc usually seen overhead is beautifully illustrated, while the shafts of light that apparently strike upward out of the horizon are nothing more or less than the concentration of the discharges as they approach the poles at the upper and lower ends of the sphere. By varying the magnetism of the globe, the radius of the globe, the light zone could be altered at will, within wide limits, diminishing with strong magnetic fields. Fig. III shows something similar, but in this case the globe (earth) itself was made the object upon which the discharge terminated. This phenomenon was even more significant, for in the belt in which the rays from the cathode descended upon the globe, is seen the remarkably beautiful effect of light zones around the earth's magnetic poles. The so-called "aurora-belts" in particular were exceptionally well reproduced. Fig. IV is a fine group showing the same sphere from three positions. In No. 1 the north pole is exposed to view with the evening side of the globe to the left. The remarkable spiral-like effect here seen is often probably visible directly overhead. In No. 2 the photograph of the equatorial belt of the globe shows in a striking manner how the auroral zones confine themselves to the extreme northern and southern latitudes, and why the phenomena is never visible very far toward the equator. No. 3 of this group shows the corresponding south polar region under the same conditions, with the morning side of the sphere to the left.

These experiments gave the first really good support to the cathode ray or corpuscular theory of the aurora.

From a mathematical point of view the corpuscular theory, however, affords a much more difficult and in some respects unsolvable problem. This phase of the problem was attacked by Carl Stormer with unusual success. He became interested in Birkeland's experiments, recalling that the problem of the concentration of cathode rays toward a single pole had been mathematically treated by no less a mathematician than Poincaré. Following up the problem, Stormer endeavored to determine mathematically the trajectories of the electric corpuscles in the magnetic field of the earth, hoping in this way he says, "to confirm not only the details of Birkeland's experiment, but also the principal features of auroras and magnetic storms." With what singular success he achieved this more than ordinarily difficult problem can be appreciated from a survey of some examples of his models here shown in Fig. V.

"If we assume," suggests Stormer, "that the sun sends out into space large quantities of electrical corpuscles the mathematical problem reduces itself to finding the paths of these corpuscles in the field of an elementary magnet." As simplifications he assumes the motions of the earth and sun to be negligible with respect to the speed with which such corpuscles travel between the sun and the earth. Since the difficulties of solution, even under these conditions, are extraordinarily complex he further assumes that the corpuscles are not affected by any forces other than the earth's magnetism, and that they follow the laws observed by the motion of cathode rays in stationary magnetic fields. Finally, he supposes for simplification of the computations that the earth's magnetism, in accordance with Gauss's hypothesis, is considered as caused exclusively by magnetic masses in the interior of the earth; further that the earth's magnetic field may be considered as equivalent to that of a uniformly magnetized sphere, or what amounts to the same thing, to that of an elementary magnet at the earth's center and its magnetic axis coinciding with that of the earth. Even with this multiplicity of simplifications the problem still abounds with unusual difficulties as we shall see.

For application to the aurora the first calculations were made with the object of finding the trajectories of corpuscles coming from an infinite distance and reaching the elementary magnet. The source of the corpuscular action was placed at infinity so that the simple case of a parallel moving stream of electrons could be considered first.

After much difficulty some trajectories were obtained that allowed the corpuscles to come near enough to a magnetized globe, to verify theoretical conclusions as to the shape of the orbits on coming near enough to the magnet. The path described by such a corpuscle is reproduced in Fig. VI, the curves being similar to the well known geodic lines of a cone of revolution, with very small opening. A view of a large group of trajectories of these corpuscles as they approach the earth, shown here as the small dark sphere, is reproduced in the three plates of Fig. V. Certain characteristic features are seen in the three views of this model. First, the large group of trajectories turning round the nocturnal (evening and night side), hemisphere of the globe, the trajectories being supposed to come from the sun. In the neighborhood of this group there are seen other trajectories encircling the globe in an undulating fashion. On the morning side we have another series of trajectories bending abruptly away from the globe. Near the early afternoon side is seen a whorl, in the center of which trajectories approach the globe in spirals as illustrated in Fig. VI. The dotted circle corresponds to the luminous rings experimentally shown by the work of Birkeland, to appear under similar conditions.

These whorls and spirals and deflected trajectories were shown by Stormer to account remarkably well for the experimental work with cathode rays, when they were concentrated on a magnetized sphere through the magnetic field generated by such a sphere. If this is true, and if Birkeland's experiments reproduce on a small scale what we actually see when we stand under the arch of the aurora, we are led to the inevitable conclusion that corpuscular rays coming from the sun contribute to the effect or account for it completely.

There remains, however, one serious objection to this hypothesis, viz., the difficulty of conceiving of the enormous velocity these corpuscles (electrons) must possess in traveling from the sun to the earth in order to penetrate to the depths of the atmosphere at which auroras occur, velocities much larger than any heretofore observed in the laboratory.

An hypothesis meeting this objection, and, hence, perhaps more acceptable, is that put forward by A. Paulsen, who assumes that an enormous ionization and electrification takes place in the upper regions of the atmosphere, through the absorption of cathode rays coming from the sun, which daily is renewed, and when intense enough becomes visible through electrical discharge. Convection currents in these layers would account for the observed and difficult to explain curtain auroras, the characteristic feature of which is what appears to be a vertically hanging curtain consisting of densely coordinated parallel rays. Luminous waves may often be seen rushing through the display, the wave appearing to pass through the entire length of the drapery.

The color of the aurora is, more easily accounted for. The spectrum of the visible portion shows a primary line of λ 557$\mu\mu$, while photographic spectral analysis has shown, during periods of great intensity, lines corresponding to λ427 and 390$\mu\mu$; during periods of less

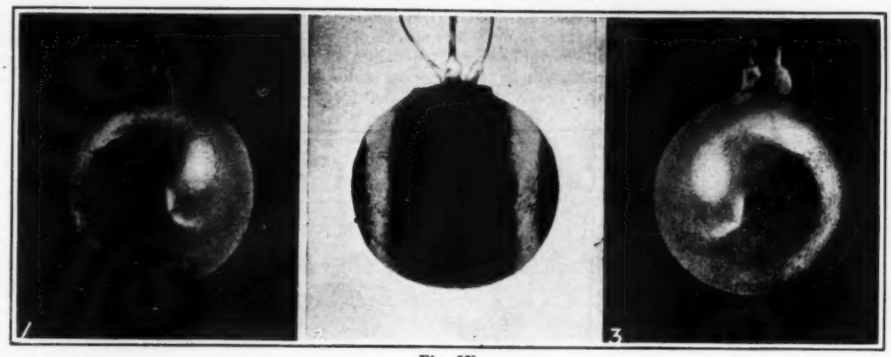

Fig. IV

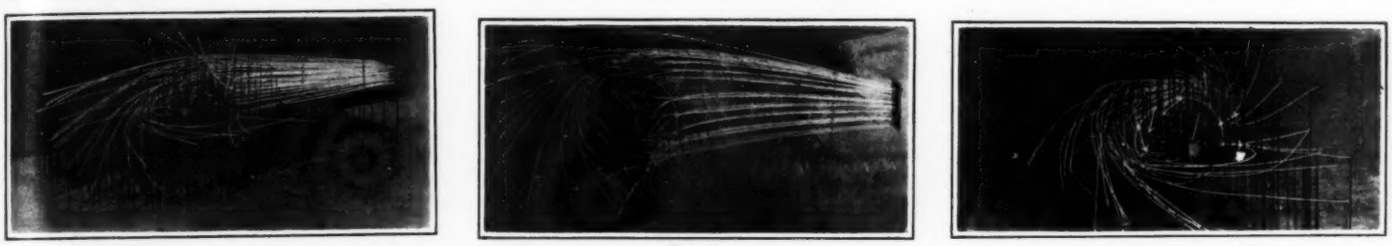

Fig. V

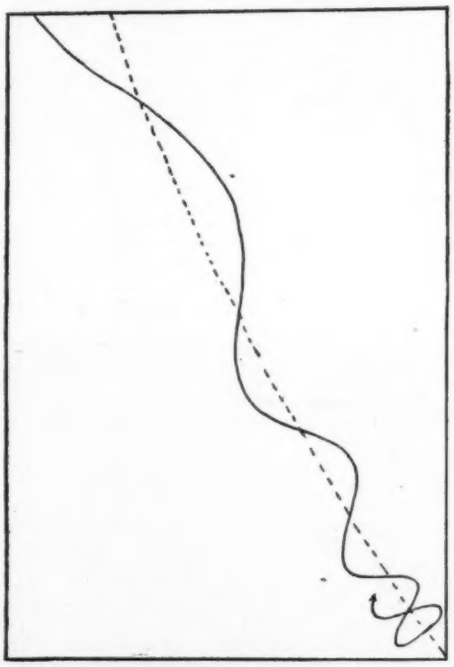

Fig. VI. The path described by a corpuscle in approaching a magnetic pole

intensity λ440, 433, 421, 407, 399, 394, 379, 374, 369, 357, 353, and 337$\mu\mu$ were observed.

The most prominent line corresponds to krypton, most of the other lines belong to krypton and such rare gases as argon, zenon, and neon.

Due to the great height at which aurorae appear one would not expect to find the spectrum lines of nitrogen and oxygen, but only those gases which through their small molecular weight are a large per cent of the composition of the rarefied air in high altitudes, or which, through their chemical characteristics, are especially susceptible to luminescence.

A complete theory including all the phenomena and meeting all the difficulties raised, is however, still expected to arrive.

The Psychology of Color—II*

Color as a Form of Consciousness

By Leonard Thompson Troland, Harvard University

[Concluded from Scientific American Supplement No. 2225, Page 115, August 24, 1918]

Another unsolved mystery of color vision is that of its evolutionary origin and its biological significance. To the layman it may seem absurd to ask "What is the use of color vision?" because there are so many practically important discriminations in our every-day life which depend upon, or at least are aided by a perception of color. However, the pertinency of the question increases when we consider, first, that nearly all of these practical situations have been created in the course of social development, because color vision already existed; and, second, that even in our complex colorific civilization the color-blind person gets along with very little difficulty, so that he may never become aware of his defect until he is carefully tested in the laboratory.

Some reasons exist for believing that originally color vision was developed as an adjunct of the reproductive function, and should be considered virtually as a "secondary sexual character." Color blindness appears in heredity to be a "sex-linked character," as it occurs some forty times more frequently in the male than in the female. The females of many species are drab, for protection, while the males are highly colored. It is not improbable that this may have been the case with the fur-coated progenitors of the human species, and that color vision is in reality a vestige of by-gone evolutionary conditions, which has now been distorted from its primitive function, the recognition of a mate.

A more plausible view is possibly to be found in the consideration that, although practically every judgment which we make on the basis of color can be made also on a basis of luminosity or shape, color discrimination greatly increases the speed with which such judgments can be delivered. The visual discriminative reactions of the color-blind individual are often slow and hesitant. The function of vision is of such tremendous importance for the welfare of the individual that any feature in its working which could add appreciably to its general efficiency would markedly increase the chances of the individual or species in the struggle for existence. Color perception, also, is more absolute than is the perception of luminosities. The tremendous changes in illumination to which the eye is forced to adapt itself make it practically impossible for the visual mechanism to evaluate luminosities save in relation to other, simultaneously presented, luminosities. On the other hand, although color adaptation occurs, its range is sufficiently small so that our color sense provides us readily with judgments of absolute as well as of relative color.

COLOR AND MENTAL EFFICIENCY

My feeling, to which I have already alluded, that the topic "The Psychology of Color," exhausted the contents of the science of color was somewhat allayed when the committee informed me, in answer to an inquiry concerning their conception of the scope of my paper, that what was desired was a discussion of "the affective value of color." My instinctive reaction to this problem was that nothing was known about it, and that probably there was nothing in it to be found out.

However, it is my good fortune to have at hand an account of the recent investigations of Dr. S. L. Pressey, in the Harvard Laboratory, on "The Influence of Color upon Mental and Motor Efficiency." Dr. Pressey's work, although of necessity limited in its scope, represents—so far as I am aware—the only systematic attempt which has thus far been made to study the relations of color to the higher psychological processes, under well-controlled laboratory conditions. In considering this subject, I shall therefore confine myself to a brief summary of his methods and results.

The problem of the *higher psychology of color* may be subdivided into the problems of color preference, and of the influence of color on mental efficiency. Both of these factors may be supposed to involve the influence of affective tone, *i. e.*, the pleasantness or unpleasantness of the color experience; or the emotional effect. The literature of these topics is fairly extensive, but it is characterized throughout by lack of scientific method and lack of agreement. Practically every color has been preferred by one group of individuals or another, in one historic period or another. All of the colors have been employed as symbols of happiness, and all as tokens of death. Statistically, the literature makes no statements; one color appears to be almost as good as another for any purpose, except that of actually copying the aspects of nature. There is some agreement that brightness and redness have a "stimulating effect," but even this is very indefinite.

Dr. Pressey's results confirm this conception of the effective neutrality and equivalence of the colors, considered as isolated factors of experience. He made no attempt to deal with color patterns or sequences, such as enter into the chromatic fine arts, but simply studied the effect upon mental performance of single colors spread uniformly over the visual environment of the subject. The colors employed in the principal series of experiments were primary red, green and blue, of about equal saturation. The subjects sat before a table which was covered with a white, unglazed paper, and this was flooded with the colored light from above, the eyes being protected from direct glare. Large gelatine filters were employed, and the brightness of the table top was in all cases about 7 candles per square meter. Pre-exposure of the eyes was given to a "normal" tungsten light, for which the colored light was substituted (without dark interval) during the test period. The exposure periods were timed systematically.

As indices of the possible mental effects of the colors, Dr. Pressey made use of the subjects' performance in a number of fundamental "mental tests," and also measured pulse and breathing rates. Previous work by Stefanescu-Guanga, at Leipsig, had indicated a marked influence of color upon respiration and heart action, but Dr. Pressey's carefully taken records show absolutely no consistent effects of this sort. Nine subjects were tested, over a period of ten to twelve weeks.

In order to test the effect of the colored light upon general muscular facility, the subjects were required to tap at a comfortable rate with the finger during one-minute periods. The five subjects employed showed no influence due to color, although significant increases in the tapping rate were obtained by increasing the *brightness* of the light, proving the test to be sensitive to the general sort of effect which was being studied. Another test of a similar nature, sensitive to changes in general neuro-muscular tone, consisted in requiring the subject to register a definite pressure with the hand upon a postal scale. The results again were negative, both for color and for brightness.

Closer contact with the immediate affective experience of the subject was obtained in a series of experiments made upon the effects of color upon the pleasantness of "touch substances." These touch substances were simply small squares of materials varying in texture. The subject passed his finger tip over them in succession, while exposed to the action of the colored light, and estimated the pleasantness or unpleasantness on a subjective scale of seven "points." Twenty substances were used, but no influence of the color upon the judgments was evident.

A further test, clearly involving mental efficiency, was that of the rate of multiplying under the colored illumination. Great care was taken to allow for practice effects in this work, and although increased brightness increased the rate of work, no specific effect due to color could be detected.

The next test to be tried was that of the so-called "free association experiment." The procedure of this experiment is simply for the experimenter to speak a single word, and for the subject to reply as quickly as possible with the first other word which comes to his mind through association. The time required for him to "think" of this latter word is taken with a stop-watch. The recall of ideas by association is of course one of the most fundamental principles of mental action. Eight subjects were tested over a long period, but no influence either of color or brightness was found. Similarly negative results were obtained with respect to the rate at which the subjects memorized nonsense syllables.

The final test employed by Dr. Pressey in his experiments is what he calls a "continuous choice reaction." In the ordinary choice reaction experiment the subject is required to react in one way if a certain simulus is presented, but in a different way if a certain other stimulus is presented. In other words his muscular response is specific with reference to the stimulus. In Dr. Pressey's continuous choice reaction, as soon as the subject has completed one reaction he is automatically presented with another stimulus, to which he must react immediately, and so on indefinitely. The number of correct reactions which he can make in a specified time determines his score in the test. This test presents in elementary form the typical situation which we face in all neuro-muscular or mental adjustments, but no appreciable influence of color upon the average performance of six subjects, could be detected; although brightness had a slight effect.

During the experiments, Dr. Pressey often required his subjects to make introspective reports concerning the affective value of the colors, as directly experienced. These reports not only showed very little consistency from individual to individual, but also varied from day to day in the same individual. Red was more often found to be exciting than indifferent, and bright illumination was usually preferred to dim, but in certain subjects the reverse was true.

Dr. Pressey, himself, would not claim that his experiments dispose entirely of the proposition that the use of color in lighting may have a practical influence upon human happiness or efficiency. The tests employed, although representative of fundamental psychological functions, were not exhaustive. It would be desirable to supplement laboratory investigations of this sort by experiments carried out with actual factory operatives working in their usual environment. However, it seems to me that Dr. Pressey's work, being carried out with 26 subjects, over a period of three years, does establish a strong presumption that the higher psychological influence of color in illumination—if it exists—is of very minor importance.

Dr. Pressey's tests were designedly selected so that their results would not depend upon any direct ocular factors, such as for example, visual acuity. Owing to the chromatic aberration of the eye, monochromatic light gives a better defined retinal image than does white light. Moreover, Nutting has shown that the eye is quite accurately corrected for achromatism in the midregion of the spectrum—the region of high visibility—but very poorly corrected in the end regions. Consequently, since in practical lighting we are forced to employ a wide spectral range, the acuity factor would seem to demand the use of yellow green. Considerations of luminous efficiency also obviously make the same demand.

It should be borne in mind that generalizations concerning the psychological effects of color may fail to apply to individual cases. The generalizations are simply averages, in which a multitude of individual differences cancel one another out. The affective values of specific colors in individual mines will depend upon the idiosyncrasies of individual experience. Psychopathic cases are not rare in which the sight of a certain color suffices to induce an hysterical fit or to arouse an emotion of terror which quite paralyzes the mind. Such phenomena, however, are due to associations of ideas based upon past emotional experience, and may occur in connection with stimuli of any sort. Uniformities in the social environment of all human beings may produce some uniformity in these associations, such as that of red with danger—blood, fire and railway signals—but actually these uniformities do not appear to be very marked.

CONCLUSION

Even if the utilization of a homogeneous spread of color in illumination should not recommend itself upon rigidly practical grounds, this would not mean that the illuminating engineer should lose his interest in color. The affective value of color lies essentially in *color combinations*, and the production of color combinations which are pleasing to the eye, although primarily a task for the

*From the *Transactions of the Illuminating Engineering Society.*

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artist, cannot always be accomplished without the aid of the illuminating engineer. Great credit is due to Mr. Luckiesh for his clear recognition of the fact that the ultimate effect produced by a painting or a piece of sculpture depends almost as much upon the manner in which it is lighted as upon the technique and ideals of the artist.

Although the principal dimension in which we combine colors to form color patterns, is that of space, those who are interested in "color music" believe that they can also be combined in a temporal sequence, with pleasing effects. Although it seems doubtful if color sequences can ever possess the affective values which characterize the tone sequences of phonic music, the illuminating engineer should lend his assistance to this new artistic enterprise, as to the world of artistic endeavor in general.

It is very important to recognize that "affective values" are by nature unstable, and difficult to attach to definite forms of stimulation. The law of affective adaptation tends to reduce the pleasantness or unpleasantness of any stimulus to a neutral level, with repetition or continuation. Only those stimuli which arouse fundamental instinctive tendencies, such as those of sex, hunger and fear, can be relied upon to yield anything approaching reliable affective results. Dr. Pressey found that this principle of affective adaptation was much in evidence in the introspective reports of his subjects.

On the other hand, the law of adaptation itself implies another principle, which is of great practical importance in the control of the affective life. This is the principle of *novelty*. Outside of the major instinctive emotions, and also to a marked extent within them, most of the pleasures of life are referable to novelty, to the achievement of new experiences. The old scenes and the old melodies pall upon us with repetition, and we look for new. We travel in order to get a change; we stage a new drama; we may even declare war in order to relieve the monotony.

What a remarkable medium for the production of novelty we possess in color, with its infinitude of tones, saturations, shades and contrasts! It may not be the function of illuminating engineering to light our streets with green in order to inhibit robbers and gun-men, or to flood our dining rooms with red to stimulate digestion. On the other hand, to provide us with an infinite variety of colors, which we can choose according to the passing fancy of the hour, may be a real service not only for the pleasure of the instant, but indirectly for our mental and moral efficiency, as it is governed by our satisfaction in living.

Factors Influencing the Spread of Parasites

THE life cycles of human parasites are varied and their method of entrance into man diverse. Consequently the conditions influencing their spread are different in different species and are often extremely complex. These conditions depend on the general environment of the host and on the special environment of the parasite, which is the host itself. The most important influences of the general environment on the parasite are produced by conditions of temperature and moisture. These factors have the greatest influence on parasites, like the hookworm and human flukes, which have free-living larval stages and are negligible in their influence on such a form as Trichinella spiralis, which passes its whole life cycle in warmblooded hosts. In Ascaris Trichuris and similar species the only free stages are the eggs, which resist changes in temperature and can endure considerable drying. The importance of temperature and moisture as limiting factors is well shown in the distribution of the hookworm, which, except in warm, humid deep mines, is found only in regions of considerable humidity in a zone falling approximately between parallel 36° north latitude and parallel 30° south latitude. These limitations are due to the fact that the free-living larval stages of the hookworm require for development a moist medium and a temperature between 60° and 90° F.

Infection by human parasites which require intermediate hosts for their development is limited by the distribution of these hosts. Malaria is not found outside the range of the Anopheles mosquito and the human flukes are limited to regions which contain suitable molluscan intermediate hosts. Often such a parasite entering new areas can become adapted to a new species of intermediate host. Fasciola hepatica, the sheep liver fluke, has spread widely over the world and has utilized as its intermediate hosts various species of the snail genus Lymnæa. The cercaria Schistosoma mansoni develops in different species of snails in Africa and South America. For this reason it is unsafe to conclude that a human parasite can not enter a new country, because the particular species which serves as its intermediate host elsewhere, is not present.

The rapidity with which a human parasite can spread is also influenced by the possibility of other animals besides man serving as its primary host. The human trypansomes develop in the blood of a number of large mammals in Africa. These animals serve as reservoirs of infection and increase greatly the danger from this disease. The prevalence of the Japanese blood fluke, Schistosoma japonicum, is greatly increased by the fact that it can develop in rats, dogs, cats and cattle as well as man.

Even more important than general environmental conditions or host relations in the spread of the parasites of man are the habits of the human host. The eggs or spores of most human parasites escape with the fæces. Such parasites depend for their spread on soil or water pollution. In civilized communities where systems of sewage disposal are highly developed, parasitism in man is rare, but under crowded or rural conditions, as in many oriental countries, or the poorer regions of the southern United States, sanitary arrangements are primitive and parasitism common. The widespread utilization of human fæces as fertilizer in some countries also contributes to the spread of parasitic infections. Often, as in hookworm campaigns, education for the improvement of the methods of fæcal disposal is a most potent weapon in eradicating the disease. Food habits greatly influence human parasitism. Ascaris, Trichuris and Oxyuris are more prevalent in children than adults, probably chiefly on account of their carelessness in eating. Uncooked vegetables, which are not thoroughly cleaned, and contaminated surface water contribute to the spread of intestinal protozoa and round worms. The habit of eating uncooked pork or rare beef serves to spread trichinosis and the tapeworm infections. The spread of paragonimiasis chiefly depends on the unusual habit in parts of Japan, China and Korea of eating raw certain small fresh water crabs which carry the encysted stages of the lung fluke. The most effective method of attack against any parasite which depends for its introduction into man on a particular food habit is an attempt to change this habit by legislation, publicity or other means. The publicity given to trichinosis about twenty years ago has done much to lessen the prevalence of this disease in the United States, by making people afraid to eat partially cooked or pickled pork.

The prevalence of parasites which infect man by penetration through the skin depends on habits which bring men in contact with infected soil or water. These diseases are therefore more prevalent in rural communities than in cities. They are also often occupational, as hookworm among miners and schistosomiasis among laborers in the rice fields of Japan.

Diseases which are carried by biting-insects are spread by habits which bring men into contact with the insect carriers. The spread of such diseases also depends on habits of man which give the intermediate host a good environment for development. For example, it has been found in the mosquito survey that in irrigated regions of California there seems to be a correlation between the water rates and the prevalence of malaria. If water is cheap it is apt to be wasted and to stand in pools and ditches. This gives ideal conditions for the development of the malaria mosquito. Where water is more expensive, it is more carefully conserved and fewer places will be produced where mosquitos can develop. The intermediate host is the most vulnerable point for attack against insect-borne disease, as has been shown many times in campaigns for the eradication of malaria and yellow fever.—*Bulletin of the California State Board of Health.*

Ancient Methods for Stripping Films

THE operation of stripping a gelatine film from the plate is one which is constantly subject to improvement. It is mainly employed in photo printing work where the image needs to be reversed from right to left. The stripped film is mounted upon a new backing, unless it is desired to keep it in the state of a simple film, but this is unusual. The method is also employed where the glass contains bubbles or streaks which would appear in the finished work, or where the plate is broken without injury to the film itself. The method of working and the products to be employed differ according to the case, that is, whether the plate is to be kept at exactly the same size or enlarged. In the first case, the plate to be stripped is put in a bath composed of water 100 parts, formol (commercial), 20 parts, sodium carbonate 5 parts. Take out after 15 or 20 minutes and allow to dry, after sponging but not washing, so that the gelatin remains saturated with carbonate of soda. When dry, cut the film around the edges with a knife at about ⅛ of an inch from the edge, then put in a bath of water 100 parts, hydrochloric acid 10 parts. The reaction of this acid on the carbonate of soda causes carbonic acid gas to be given off, and the gas raises the film so that it separates from the glass. Then pass under the film a glass plate previously rubbed with talcum powder and then covered with a layer of collodion, and remove from the tray, avoiding air bubbles. Expel the excess of water by passing a composition roller over the film, and let dry. Then cover the film with a coat of collodion (3 per cent), to which has been added a small amount of castor oil. When this coat is dry, the film easily comes off the glass, and is protected on each side by the collodion. In case the image is not to be kept in its original size, but is to be enlarged by the expansion of the gelatin, it is only required to suppress the formol in the first bath. Then the film, when in process of stripping, undergoes a considerable extension, which varies with the nature of the gelatin and the temperature of the baths employed. In this case the plate is to be placed in a rather large tray, and the film should be laid on a plate of sufficient size, or about double the size of the original plate. Stripping with expansion of the gelatin can also be carried out by the use of a single bath. A simple immersion in a 10 per cent hydrochloric acid solution is usually enough, but this result is not always reliable, and it is safer to put the plate in a 10 per cent solution of fluoride of ammonia. When the gelatin is loosened from the glass, empty the tray with care so as not to damage the film, which is rather fragile, and then pour in pure water. Then put in the new glass plate which is to receive the film. If the film is to adhere to the latter permanently, this plate should be well cleaned, but if it is to be separated from the plate, the latter must be rubbed with talcum and treated with collodion as in the first-mentioned case. Of course when the film is extended, it loses in thickness what it gains in surface. In fact, the surface is about doubled, and hence the density of the image is reduced one-half. For this reason, the plates to be used for stripping and enlargement must be developed farther than usual, or the image must be strengthened either before or after the transfer. But in the latter case, collodion is not to be used.

Imports of Palm Oil

PALM oil is largely employed in the manufacture of soap and candles, and also in the tin plate industry, the heated iron plates being covered with palm oil to prevent oxidization before they are dipped in molten tin. This product can now be refined to a pure tasteless oil which is used in the manufacture of margarine. There is an abundant supply of palm fruits available in West Africa, as large areas of forests are still untouched. Palm oil is obtained from the pericarp or outer pulpy layer of the fruit of the West African oil palm (*Elaeis guineensis*), while the kernels are secured by shelling the palm nuts which are left when the pericarp is removed from the fruit. The kernels yield from 46 to 53 per cent of a white or pale yellow solid fat, possessing a pleasant nutty taste and resembling cocoanut oil in appearance and properties. This fat or oily matter from the kernels is used in the manufacture of soap and candles and in the preparation of edible fats, such as margarine, cooking fats, vegetable butters and chocolate fats. The oil cake or meal left after the pressing process is of value as a cattle food. The imports into Great Britain of oil-producing nuts and kernels (most of them being palm products), amounted in 1916 to 373,018 (long) tons, valued at $42,660,160. The imports of palm oil into Great Britain in 1916 were 24,177 tons, valued at $10,994,920. The greater part of these products come from Nigeria, Sierra Leone, Gold Coast and Gambia. A considerable number of crushing mills have now been established in Great Britain for treating the palm products. Nut butter, or margarine, into the composition of which the oil of the kernel largely enters, is now recognized as a nutritious form of diet, and will hold its place on the market even when the present inflated price of butter becomes normal.

Waterproofing Compositions

ACCORDING to a recent British patent fabrics are rendered waterproof by treatment with compositions containing gum tragacanth and other materials. For tarpaulins, etc., gum tragacanth dissolved or suspended in water is mixed with acetate of lead or sulphate of alumina. Acetate of lead and sulphate of alumina may be mixed together, and the clear solution of aluminum acetate may be applied to the fabric, or the fabric may be treated with the solutions separately, in which case sulphate of lead is precipitated in the fibers. For lighter fabrics, the gum tragacanth is mixed with soap dissolved in alcohol, and then with the sulphate of alumina or acetate of lead, or both. A third preparation consists of gum tragacanth mixed with linseed oil and a small proportion of terebene or gold size.—*English Mechanic.*

Press Illustrating Service

Heavy porter work performed by women

Material arriving at the sorting depot

National Economy in England

One of the possibilities of the result of the war is universal national bankruptcy, for there is a limit to the wealth of the world, and when the cost of the contest runs up into the millions for every day of its continuance it is evident that a few years more will have serious results that will be felt throughout the world for years to come.

Of course success demands liberal expenditures, and money and materials cannot be stinted. Ample supplies must be maintained at any cost, no matter how prodigal, but even in doing this there is such a thing as reckless and needless expenditure, and careful management of our material resources is necessary lest they be exhausted before our man-power is.

At the commencement of the war the Allies, all unprepared as they were, found it necessary to pour in their money without reckoning the cost; but as conditions settled down the necessity for economy began to be realized, and with more complete organization systematic conservation of materials was developed. In a previous issue there were a number of illustrations showing how used war material is being salvaged in France; and in the accompanying photographs we see what England is doing in the same direction at home. Much material can be renovated on the spot, but there is still a large amount that cannot be so treated, and the British are carefully collecting such material and sending it back home, where it can be properly worked over in the factories that originally produced it, for re-use. The views show one of the great salvage yards that have been established in England, and here we see immense quantities of artillery cartridge cases, packing tins and the like being sorted, in which work women are being extensively utilized. It will be seen that the salvaged material arrived at this yard mostly in cases, being delivered direct by rail and by barges; and that extensive systems of traveling sorting tables have been established, which greatly lighten and expedite the work. After the material has been sorted and classified it is re-packed and sent to factories in different parts of the country, where it is overhauled and repaired for future use.

When we consider the tremendous expenditure of ammunition by the artillery that is constantly going on every day it can be realized the immense quantity of brass that is necessary for the cartridge cases, and brass, on account of its copper content, is not only a very expensive material, but a serious drain on our supplies of copper, which is such a necessary material for many other purposes as well. If all of these cases can be saved, renovated and used again several times, not only is a great expense saved, but adequate supplies of material are insured. So it will be seen that such carefully organized salvage operations as are illustrated in the accompanying pictures, and those previously published, are a most important national economy.

The Ornithopter

By Herbert Chatley, D.Sc. Lond., A.F.Ae.S., M.Inst. C.E.I.

There is very little probability that any new form of flying device will be originated during the Great War, since the talents and experiment necessary can be more usefully devoted to the improvement of the airplane. The latter has proved so successful that there is small prospect that any rival could develop to a comparable degree of efficiency in the present environment.

Nevertheless it cannot but be of interest once again to consider, in the light of our greatly advanced knowledge on the subject of flight, the problem of the real bird machine. That type promises certain things which it is difficult to conceive the airplane can ever supply, the lack of which constitutes almost its only serious drawback. These are:

(1) The ability to rise without forward speed.

(2) The ability to land without great velocity relative to the earth.

(3) The ability to hover.

There is also the possibility of a higher efficiency, but this is somewhat uncertain.

On the other hand, it seems certain that an ornithopter would have certain undesirable qualities which may prove insuperably harmful. These are:

(1) Mechanical complexity.

(2) High structural stresses.

(3) Variable dynamic stability.

(4) Small rigidity in the supporting surfaces.

(5) Intermittent support.

In spite of the partial success of some flapping models, it is by no means quite clear how wings, properly so called, act. The naturalist school differs widely in its opinions, and even the Marey sphygmograph records are not decisive.

There are two types of difficulty:

(1) Ignorance as to the aerodynamic reactions on an oscillating wing.

(2) The complexity and continuous change of the mechanical conditions of equilibrium.

The first is got over (it may be to some extent incorrectly) by assuming that at any one moment the reactions are the same as would occur in a state of similar but steady motion.

As far as the second is concerned, two obvious conclusions occur:

(*a*) The mean upward thrust must be equal to the weight supported.

(*b*) The mean forward thrust at constant horizontal speed must be equal to the horizontal resistance.

The resultant thrust must then be upwards and forwards. It does not, however, wholly necessarily follow that the effective wing stroke must be downwards and backwards, as Pettigrew believed, since the horizontal velocity must be taken into account. If the wing moves vertically downwards relatively to the body it will provide a forward thrust component if it slopes downwards and forwards at an angle of a value between certain limits. These limits are difficult to fix. The resultant motion of the wing with respect to the air is composed of the vertical velocity relative to the body and the horizontal velocity of the whole machine. In order that there shall be any lift at all the chord plane must have a positive angle of attack with this direction of resultant motion. Hence the superior limit to this angle of depression is the direction of resultant motion. In order that the drag shall be overcome the resultant force on the wing must have a forward component, and the angle of attack at which this vanishes (*i.e.*, the thrust becomes perpendicular) determines the lower limit.

On the upstroke the reaction is downwards if the angle of attack is negative and backwards if the angle of attack is positive. Since energy would then be consumed uselessly in either case, I deduce that the angle of attack on the upstroke should be zero—*i.e.*, the wing should run in the wind, which means that the chord plane coincides with the direction of relative motion. There is, of course, a small frictional drag downwards and backwards, but this cannot be eliminated. If the upstroke is made in the same time as the downstroke (any increase of speed would increase this harmful skin friction and also change the direction of absolute motion, but nevertheless may be permissible), then during the downstroke the mean vertical force must equal twice the weight, and the mean horizontal forward force must equal twice the mean horizontal resistance. The machine will necessarily fall somewhat during the upstroke, so that the period must be short (there is a suggestion here of a relation between the period and size, but I am not clear what it is), and it may be necessary to take into account the velocities developed during this fall. Such a vertical oscillation is quite apparent in the flight of large birds.

Rayleigh has made a brief analysis on these lines, and I developed the argument mathematically some years ago in the *Journal* of the Junior Institution of Engineers.

A complete investigation must proceed to deduce the proper wing positions at all horizontal speeds, and there seems little doubt that there is a general relation between the period, angles of twist, horizontal speed, wing area, span, and weight.

Presuming this problem solved and the conditions of dynamic stability are also settled on the lines laid down by Bryan, it only remains to consider whether the fundamental assumption as to the reactions is true, and I have no doubt at all that some modifications must be introduced. The following considerations enter into the question:—

(1) A purely mathematical one. The root of the mean square is not the same as the mean, so that if the velocity varies periodically the mean resistance is not the same as the resistance corresponding to the mean velocity.

(2) The accelerations of the air stream relative to the wing will cause additions, positive or negative, to the reactions.

(3) The "wake" will move about in a complex manner, which will cause the addition of a "virtual mass," which may or may not be of importance. Fitzgerald has suggested this as a means of assisting sustentation.

(4) The rotation of the wing introduces new torques of possibly important amount.

Some light can be thrown on these questions by experiment with oscillating propellers, such as Cooper's, or the fish-tail type used in China and elsewhere for boat propulsion, and with fixed or oscillating airplanes in a pulsating current.—*Aeronautics.*

Use of Chromic Acid and Hydrogen Peroxide as an Etching Agent

For etching brasses and bronzes before microscopical examination, a dilute solution of chromic acid, to which a few drops of hydrogen peroxide has been added, is advised. The addition of the hydrogen peroxide causes a strong effervescence and turns the solution of chromic acid a very dark green. If the chromic acid solution is too strong, large gas bubbles are evolved which prevent uniform etching. When the right strength of solution is used, the immersion of the specimen causes a spitting of the liquid, particles of which are projected from the bath on to the sides of the containing vessel.

In the case of copper tin alloys the α is not stained, and the δ remains a light blue. In the copper-zinc alloys both the α and β are said not to be changed in color, while in rolled brass the grain boundaries and twin crystals are brought out with great clearness. This reagent also gives good results with silver alloys.—Note in Sci. Absts. on a paper by S. W. Miller before the Inst. of Metals.

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A corner of the immense yard, showing traveling sorting tables

Packing artillery cartridge cases for return to the factories

How Can Soft Coal Be Burned Without Smoke in Marine Boilers?*

The avoidance of smoke would decrease the radius of visibility of our ocean carriers by many miles and greatly reduce their liability to attack by submarines. If efficiency is improved incidentally it means much more than the mere coal saving.

ALBERT A. CARY. It has been repeatedly asked how to avoid the production of smoke from the steam-generating equipments of transatlantic vessels under the present conditions of submarine menace. It is an extremely vital question which has seemed to evade its answer most adroitly. After having studied this matter carefully for some time, in the light of almost thirty years' experience with most of the special furnaces and smoke-suppressing devices in this country, and many of those abroad, I can state without qualification that this trouble *can* be met, practically and satisfactorily, provided our marine friends are willing to meet us half way in their new constructions and make a compromise between old, time-honored marine-boiler practice and successful land practice.

Although an innovation, this does not mean drastic changes from their present form of steam-generating equipment; it simply means getting sufficiently away from the furnace practice long followed which has caused the submarine-signaling smoke nuisance.

The question submitted in this topical discussion is very simple and direct, and equally direct answers might be given by stating: suppress the fires in the furnace by firing in such small quantities as to prevent the emission of smoke; or, secure *complete* combustion in the furnaces and combustion chambers. The first-named method, of course, must result in a serious loss of the vessel's speed. The second method gives the only wholly rational solution of the trouble.

The average types of marine boilers with their present form of attached furnaces make it well-nigh impossible to secure complete combustion within the furnace in such a way as to suppress smoke without sacrificing efficiency. On the other hand, it is possible to make rational changes in the steam-generating equipments for new ships so as not only to suppress the smoke nuisance, but to carry vessels through the danger zone at their highest speed.

To accomplish this highly desirable end by working along the lines of the latest successful developments in land practice, we shall probably require 4 ft. more headroom, in which to place the boilers, but even should 5 ft. be demanded, the tremendous advantage gained would far offset any objections that could be raised to this innovation in the marine-boiler practice of the past.

To illustrate, I will refer to an equipment for stationary boilers in which I have been interested from a purely professional standpoint, and which can be practically adapted to marine service in new vessels to secure high rates of coal consumption without producing objectionable smoke.

Eighteen stokers have been operating 500-h.p. boilers 24 hours per day continuously for two years, at 50 per cent above their rating, with average grades of eastern bituminous coal of no better quality than is used by transatlantic ships. They have been continuously burning from 42 to 45 lb. of coal per sq. ft. of grate per hour, with a clean smokeless chimney and have shown an easy forcing capacity when over 60 lb. of this eastern bituminous coal is burned per hour per square foot of grate.

The coal is fed from the hopper to the fuel bed in a steady flow in such manner as to avoid the trouble usually following its coke formation and the troublesome caking, and then it is moved along the grate automatically so as to constantly drop its ash directly down to the grate surface where the cool entering air keeps the temperature of the ash below its fusing point, thereby avoiding the formation of obstructing clinker.

The resulting ash is dumped into an ash-sealed pit where it is water cooled and an automatic ash-removing device carries it forward into the front ashpit without disturbing the ash seal and without disturbing the draft conditions of the furnace.

The deep fuel bed is always kept in an open porous condition over its entire surface like a huge sponge, thus requiring a light air-blast pressure, seldom exceeding 1-in. water pressure and allowing each stoker to be operated with an individual disk fan (requiring but little power to operate) instead of the usual heavy steel-plate, forced blast fan with its voluminous air ducts. The result is not only a saving in power required for operation but also a material saving in space requirements.

With the clinkering trouble in firebed, side and bridge walls thus avoided, hand cleaning of the firebed is almost entirely done away with while the firebed is easily kept level and of uniform thickness by an arrangement of the automatic-feed device.

Adjustment of the rate of coal feed is quickly and easily changed (along with the speed of the fan) and thus, with the free-burning firebed conditions existing, a jump from low to high steaming capacity in the boiler is obtained in a very few minutes.

With such exceptional fuel-burning conditions under marine boilers, the production of smoke would be prevented by securing practically complete combustion in the furnace, and the highest steaming capacity of the boiler obtained to take the vessels through the danger zone at high speed.

With the coal supplied to the furnace by simple conveying apparatus and with ash delivered from the ashpit automatically by the stoker and conveyed overboard automatically, hand manipulation can be almost entirely done away with and a happy solution secured of the present difficulty in getting the greatly needed expert firemen.

OSBORN MONNETT. As to whether soft coal can be burned without smoke in marine boilers, there can be but one answer: Yes. As a purely engineering problem it is feasible. Of the methods tried for this work the underfeed principle has been best adapted. With this method the headroom and ashpit facilities may be put to a minimum and the auxiliary machinery required is comparable to that ordinarily used for forced draft hand-fired furnaces. Furthermore, this principle of burning soft coal is well adapted to the character of the load (variable speed, etc.) and handles to good advantage the class of coal customarily used for marine purposes on our eastern seaboard. Theoretically, all points are in its favor.

Moreover, considerable practical experience has been gained with underfeed stokers in marine work in the past ten years. A number of marine installations are operating successfully today, among which might be mentioned the following: steamer *Sprague*—6 Scotch marine boilers—12 stokers; tug *Perfection*—1 marine firebox boiler—1 stoker; tug *Mollie Spencer*—1 marine firebox boiler—1 stoker; dredge *Wm. O'Connell*—2 double-end Scotch marines—8 stokers; steamer *Gamma*—6 tubular boilers—6 stokers; dredge *Hecla*—2 Scotch marine boilers—2 stokers; Ward Engineering Co. steamers—2 Ward marine water boilers—4 stokers Holland-America Line steamer, *Frederick VIII*—8 Yarrow boilers—16 stokers.

These installations, all of the Jones underfeed type cover a wide variation of marine service from dredge and river steamers to transatlantic liners, and all types of boilers, including Scotch marine, marine firebox and water-tube boilers, of both straight- and bent-tube varieties.

The problem is not so much a mechanical one as it is one of the human element. Put one man (fourth engineer) who is familiar with this type of equipment on duty on each watch and no difficulty need be experienced. The necessary men could be recruited from the large number of power plants in this country now using underfeeds.

As far as hand firing with Scotch marine boilers is concerned, experience has been discouraging. The writer once succeeded in operating smokelessly a steamer so equipped, without any apparatus, simply by changing alternate fires. It happened that the boilers, two in number, were equipped each with three corrugated furnaces, all discharging into a common combustion chamber. The volatile matter from the fresh fire was consumed by the hot gasses from the other two fires. With two furnaces the results would have been less satisfactory, and with separate combustion chambers (a common construction) impossible.

The idea in hand-fired furnaces has been to mix the gases, after they pass the bridge wall and while they are at a high temperature, with an auxiliary supply of air, and so accomplish complete combustion. Experiments have been made in Chicago harbor with brick arches, baffles and other constructions calculated to do this, but the small space available in the Scotch marine boiler has prevented satisfactory results. In fact, the writer's experience with forced draft, induced draft, special air admission, preheated air, panel doors, steam jets, induction tubes, stack blowers, hollow bridge walls, etc., etc., has led to the conclusion, more strongly than ever, that some type of underfeed stoker is the logical answer to the Scotch marine boiler problem.

In water-tube boiler construction, such as has been adopted by the Emergency Fleet Corporation, there is more opportunity to do things and it is not unreasonable to hope that a satisfactory hand-fired furnace for these units will be developed.

*From the Symposium of the Am. Soc. of Mech. Engineers at the annual meeting at Worcester. From the Journal of the Society.

Valonia Tanning Material

AMONG the various tanning materials may be mentioned valonia, which consists of the acorn cups of the valonia oak. Asia Minor is the principal source of this tanning material, and there are factories in Smyrna for the preparation of a concentrated extract of valonia. Supplies from Asiatic Turkey have been greatly reduced owing to the war. The importance of the valonia oak as a source of tanning material has led to attempts being made to grow it in other countries, including Australia and Algeria. So far, however, there has been no production of valonia on a commercial scale in either of those countries. The tree is of comparatively slow growth and does not yield an appreciable quantity of fruit until 15 years old. It is, however, a tree of handsome appearance, yielding good timber. Valonia produces a firm leather, light in color and of good weight. It is chiefly used in the manufacture of heavy leather of high grade, such as sole leather.

Substitutes for Wheat*

Employed in Making Bread for the French Army

Editorial Note: The following article by a correspondent of the French Academy of Science, M. Balland, gives a valuable series of analyses of the various flours used as substitutes for wheat flour, and derived from peas, beans, seeds, nuts, roots, etc., as well as from other forms of grain.

Because of the difficulties which have arisen in the provisioning of the army, the following products have been proposed as substitutes for wheat in the manufacture of bread for the French troops:

Peanuts.—Peanut flour obtained from the cake left after the extraction of the oil can be used as a substitute for wheat without inconvenience, provided the percentage is not very large. When 15% or more is used bread making becomes more difficult; the bread is heavy and black like rye bread. Peanut flour contains 9.75% of water; 55.82% of nitrogenous matter; 0.78% of fats; 28.75% of starch and cellulose; 4.9% of ash.

Oats.—Oat flour has not been tested in the making of army bread since the reserves of oats are barely enough for the cavalry.

Chestnut.—There have been many propositions for the employment of the chestnut flour which is so popular in Corsica, but these flours yield cake or biscuit, and not bread, as Parmentier[1] stated in 1780. It appears to be more advantageous to make use of the chestnuts either boiled or roasted, and to utilize the flour in the form of a thick soup.

Cotton.—This flour, which is extracted from cotton-seed cake, is a coarse powder in appearance, and the paste or dough that it forms lacks cohesion. It contains 7.90% of water; 51.18% of nitrogenous matter; 11.25% of fats; 23.80% of extractive matters and cellulose, and 5.87% of ash. It is very alterable in character. When first made it has an acidity of 0.128%, but this rapidly increases to 0.418%. The researches of Prof. Cornevin of the Veterinary School of Lyons have provided that the kernels of cotton seed contain principles which are susceptible of being transformed into toxic agents; moreover, fatal accidents have been observed a number of times in the case of farm animals fed on cotton seed cake; therefore no test of this product has been made in the army.

Fenugreck.—The Fenugreck (*Trigonella Faenum-graecum*), whose composition is similar to that of the chick pea, and which is considered excellent as a fertilizer[2], has been proposed by the Administration of the North of Africa. The tests, however, gave unfavorable results, since even 1% of the fenugreck powder imparts its own peculiar odor to the bread.

Broad Beans.—Flours made from *fèves* or broad beans, especially those from Morocco, with a bolting percentage of 79 to 80, have been employed without injuring the flavor of the bread in amounts of 4 to 5%. These Morocco broad beans contain 10.56% of water; 25.50% of nitrogenous matters; 1.44% of fats; 59.34% of starch and cellulose; 3.16% of ash.

Haricot Beans.—Considerable quantities of Brazilian haricot beans have been employed in the same manner as the broad beans and have an equal food value.

Maize.—Maize flour bolted at 86 to 92 imparts a slight flavor to the bread when as much as 10% is used. 15% to 20% can be successfully used, but more care must be taken in the bread making, and the crumb of the bread is harder. This flour contains 11.50% of water; 8.95% of nitrogenous matter; 4.05% of fats; 73.18% of starch and cellulose; 1.32% of ash.

Manioc.—The Manioc flour sent to France by the Chamber of Commerce of Tananarivo was greyish white in color, rough to the touch, and lacks cohesion when squeezed between the hands. The dough obtained with cold water has no binding quality, but with boiling water it yields even in small amounts a starch of proper consistency. This flour contains 12.60% of water; 1.96% of nitrogenous matter; 0.44% of fats; 84.20% of starch and cellulose; 0.80% of ash.

It has an acidity of 0.48%. It contains hydrocyanic acid in very slight quantities (0.0013%). This acid is a normal consitituent of the roots of the manioc, sometimes in poinsonous amounts, but it is leached out in the frequent washings which the roots undergo in the course of being transformed into alimentary products (cassava, tapioca, white and yellow couac). From 10% to 20% of manioc flour can be introduced into bread. The bread is more easily made with this than with rice flour. A comparative anaylsis of pure wheat flour and of a mixture of 80% of the same flour with 20% of manioc, gives the following results: The former contains 13.96% of water, 10.93% of nitrogenous matters, 1.34% of fats, 73.12% of starch and cellulose; 0.65% of ash. The second contains 13.68% of water; 9.13% of nitrogenous matter; 1.16% of fats; 75.35% of starch and cellulose; 0.68% of ash. The first contains 34.5% of moist gluten, an amount equal to the amount estimated. The second contains 24.3% of moist gluten against 27.6% as estimated.

Millet.—Flour from the long millet of Algeria (*Alpiste Phalaris*), bolted at 55, was proposed to be used in amounts of 3 to 4%. This flour is very rich both in nitrogen and in fat. It must be employed shortly after milling since it alters very quickly. Analysis shows it to contain 12.52% of water; 15.70% of nitrogenous matters; 6.28% of fats; 62.30% of starch and cellulose; 3.20% of ash.

Barley.—Experiments with 10%, 20% and 30% of barley flours bolted at from 68 to 78 gave very favorable results. The crumb of the bread keeps fresh longer than ordinary bread. Barley flour contains 11.30% of water; 10.76% of nitrogenous substances; 1.98% of fats; 74.26% of starch and cellulose; 1.70% of ash.

Chick Peas.—The chick peas obtained from Spain and from Algeria we found to go as high as 93% of flour suitable for bread making. This flour can be utilized under the same conditions as that from broad beans or haricot beans. The flour contains 11.61% of water; 18.10% of nitrogenous matters; 4.86% of fats; 62.81% of starch and cellulose; 2.62% of ash.

Potatoes.—The tests prescribed by order of the Government in a number of military bakeries failed to give advantageous results. Experiments were made simultaneously with 20% of cooked potato flour and of raw potato flour, in each case 80% of wheat flour being used. Some bakers have succeeded very well by adding boiled potato flour in small quantities to fancy breads, but the case is not the same on such an extensive scale as that of the manufacture of bread for the army.

The yield of bread was less and the cost was greater, the pealing, grating or grinding, and cooking of the potatoes requiring more labor, and the purchase of special utensils. Similar results were obtained from tests undertaken at the same time by the Municipal Administration of the City of Lyons.

Analyses of breads containing potatoes made 48 hours after baking (August, 1917):

1. Bread made with 80% of wheat flour and 20% of cooked and peeled potatoes, yield=128.3: This bread contained 39.90% of water; 9.13% of nitrogenous matters; 0.19% of fats; 48.98% of starch and cellulose; ash[3] 1.80%.

2. Bread made with the same percentage of flour and 20% of raw potatoes peeled and grated; yield=126.9. This second bread contained 39.20% of water; 9.10 of nitrogenous matters; 0.18% of fats; 49.93% of starch and cellulose; 1.59% of ash.

The wheat flour with a bolting percentage of 85 contained 14.40% of water and 14.02% of nitrogenous matters. The yield of bread was 132 kilos per 100 kilos of flour; in the bread containing 39% of water there was 9.84% of nitrogenous matters.

Rice.—Rice flours with a bolting percentage of 95 give good results in bread making up to the proportion of 15%. From 15% to 20% the bread is harder to work and is less developed; the crumb is more compact and has a tendency to crumble.

Rice flour contains 12.86% of water; 9.45% of nitrogenous matters; 0.20% of fats; 77.07% of starches; 0.42% of ash.

Buckwheat.—When more than 15% is used buckwheat flour, bolted at 72 gives a black bread which is not very agreeable. In the villages of the Bresse, where buckwheat is cultivated on rather an extensive scale, there has been a return to the waffles which were such an important article of consumption some 60 years ago. Buckwheat flour contains 16.52% of water; 8.74% of nitrogenous matters; 1.66% of fats; 71.13% of starch and cellulose, and 1.95% of ash.

Rye.—Rye flour with a bolting percentage of 67 to 78[4] has been employed in the proportion of one third and more corresponding to the maslin flours (consisting of a mixture of wheat and rye) with a bolting percentage of 75.

Soy Beans.—The tests of the soy bean made in the bakery connected with the laboratory of the Invalids by the Officer of Administration, M. Chatelain, were more satisfactory than those with any other of the leguminous plants (peanuts, broad and haricot beans, chick peas). Soy bean flour exerts a more intensive action on the gluten of wheat than that usually attributed to the flour of broad beans. The most substantial breads containing 10 to 15% or more of soy bean flour slightly browned are very well flavored and keep fresh for several days.

The composition of the flours employed was as follows: The wheat flour contained 12.64% of water; 12.05% of nitrogenous matters; 1.48% of fats; 73.11% of starch and extractives; 0.72% of ash; the soy bean flour contained 6.98% of water; 42.00% of nitrogenous matters; 18.93% of fats; 27.47% of starch and extractives; 4.62% of ash. The acidity of soy bean flour shows that it is very alterable.

Sorghum.—Sorghum was not included in the millions of quintals of cereals received from Algeria and Tunisia at the beginning of the war. Since then sorghum flour with a bolting percentage of 47 has been employed for bread making under the same conditions as millet.

Flour Obtained by Beating Flour Sacks.—The foregoing title is applied to the residual flour obtained in warehouses by the mechanical beating of sacks which have held flour. This product is more or less grayish in color and contains debris from the sacks together with all sorts of bodies which feel gritty to the teeth. Upon incineration it yields 3 or 4% of earthy matters. As high as 20% of black gluten of defective character can be extracted from it. The use of this material, which was suggested in 1917, has been formally excluded from the food supplies for troops, even for the purpose of "flouring" the bread.

REMARKS AND CONCLUSIONS

The various substitutes act differently upon the gluten of the wheat. Manioc flour at 10 to 20% lowers to 28 and 24 the gluten of wheat flours containing 33% of it. Under the same conditions the flours of rice, maize and barley give approximately 29 and 26. Haricot, peanut, and soy flours at 10% give respectively 24, 27, and 30. In the last instance, especially in the case of the soy, the bread-making is more readily achieved.

The breads containing substitutes retain more water (38 to 41%) than the breads without admixture.[5] The alimentary value is sometimes decreased, but this divergence is of less import to the soldier, who has a heartier ration at command, than to the civilian of 60 years who has only 200 grammes of a bread which has a much higher water content than the former bread of 29 to 30%.

Because of the control exercised over the cleansing of the grain the extraction percentage of the military millings is generally superior to that of the substitutes mentioned in the decree of Nov. 30, 1917.[6] The general alimentation of the troops today is much superior to that of the population at large. The war bread, in particular, is exclusively prepared, as formerly, of wheat having a bolting percentage of 70. Hence our army enjoys a state of health unknown in our previous wars.

*From *Revue Scientifique*.

[1] Treatise upon the chestnut, Paris, Manory 1780; Alimentary Chemistry in the Works of Parmentier, Paris J. B. Bailliere, 1902.

[2] Vide: Alimentary Substances, II, 70. J. B. Bailliere, Paris, 1907.

[3] Of which chloride of sodium equals respectively 0.56 per cent and 0.41 per cent in the two kinds of bread.

[4] The following results for flours capable of 100 per cent panification made from cleansed grain were obtained at Siege de Javel Mill: November, 1916, 69.2; December 1916, 69.1; January 1917, 67.3, February 1917, 73.0; March 1917, 67.0; June 1917, 78.3.

[5] Examples: Bread made of 95 per cent wheat and 5 per cent haricot contains 37 to 41 per cent of water; 85 per cent wheat and 15 per cent maize = 38 per cent water; 85 per cent wheat and 15 per cent barley = 40 to 41 per cent water; 95 per cent wheat and 5 per cent chick peas = 40 per cent water; 90 per cent wheat and 10 per cent rice = 39 per cent water; 85 per cent wheat and 15 per cent buckwheat = 39 per cent water; 85 per cent wheat and 15 per cent soy bean = 41 per cent water. All these breads were examined 48 hours after being taken from the oven.

[6] Article 37 of the Decree of Nov. 30th (Official Journal of Dec. 5th, 1917). "Flours made from substitutes must have the following percentages of extraction: Maize 80 per cent, Maslin (mixture of wheat and rye), 75 per cent, Broad beans, etc. (*Fèves* and *feverolles*), 74 per cent, Rye 70 per cent, Barley 65 per cent, Buckwheat 67 per cent, Sorghum 47 per cent.

Science Applied to War

THE Kaiser has sanctioned the founding of an institute in which men of science will cooperate with the military to discover and develop new means for the purposes of war. The work will be carried on in six departments, namely: (1) Department for chemical raw materials and plant used in the production of munitions; (2) Department for chemical war materials, such as gunpowder, high explosives, asphyxiating gas, etc.; (3) Department for physics, including ballistics, telephony and telegraphy, range-finding, etc.; (4) Department for mechanical transport under war conditions; (5) Department for aeronautics; and (6) Department for the selection and preparation of metals.—*Z. angew. Chem.*

Position-Light Signals for Railroad Service*

By A. H. Rudd

PERHAPS this talk should be prefaced by a few remarks to those who may not be familiar with railway signaling, and about the system or systems in vogue for the moving of trains over our railroads, entirely under signal indications. While various types of signals, such as banners, targets, disks, etc., have been in use for a great many years, the semaphore arm, which as its name indicates, is a position signal, the indications being given by the various positions of the arm—was one of the first signals introduced.

It was borrowed from the Navy. England was the pioneer in railroad signaling. Almost as soon as railroads were established, England devised a signal consisting originally of an arm mounted on a mast or post ordinarily concealed in a box or in the mast. When it was desired to stop a train the arm was pulled up to the horizontal position. If there was no signal displayed the train proceeded. Eventually the time came when the pulling wire broke, the train was to be stopped and did not, and there was a smashup. Then some bright mind decided that they ought to give a signal to proceed as well as to stop. They arranged it so that the arm instead of being hidden in the box extended out to the side. They kept the horizontal position for stop and inclined the arm downward to proceed, and then put a big counterweight on the opposite side of the arm so as to pull it up to the horizontal position if anything broke. The Germans used the upward position of the arm before the English. In fact, the English did very little of that work. Some 10 or 15 years ago we began to change in this country and now quite a considerable part of the mileage is signaled by what we call "upper quandrant signals." That is, the arm is pulled to the clear position above the vertical or upward to the inclined position and if anything breaks the weight of the arm carries it to the stop.

Snow or ice or anything of that kind accumulating on the arm tends to make it a safer signal by causing it to drop to the stop position. As we proceeded with the development of signaling we found we should have a caution indication—an indication that the next signal was at stop. We used two arms, the top arm inclined downward and the second arm with a fish tail end horizontal indicated caution, and both arms down indicated proceed. Now we do all that with one arm; horizontal for stop, 45 degrees upward for "proceed, prepare to stop at next signal," and vertical for "proceed at normal speed."

When cross-overs were introduced we had to provide other indications. I have shown you the principal ones on the blackboard. With the semaphore signal of course you cannot eliminate the arms. With the position lights signals the old semaphore arm positions are replaced by rows of lighted lenses.

We have a number of cases in congested districts where it is practically impossible to make the blocks long enough for a fast train to stop and still handle our traffic. As an example, take our Pennsylvania line between Summit Avenue, Jersey City and Manhattan Transfer. The rapid transit trains, the Hudson tube trains and our own trains have different speeds; there are slow freight, some express, and some local trains. It is necessary to have a block practically 4,000 ft. (1,220 m.) long to stop on the level from 70 miles (110km.) an hour. On the other hand it is necessary to have blocks fairly short in order not to congest the local traffic. So instead of having the ordinary arrangement of covering two blocks so that if signal indicates stop, the next one in the rear will indicate stop at next signal, and the next one will indicate "proceed", we have introduced the system whereby if the first signal is at stop, the next signal back indicates "prepare to stop at next signal," the next on back of that indicates "pass next signal at 30 miles (48 km.) an hour," and the next one back of that indicates "proceed." A fast train passing the third signal has room to slow down from 70 miles to 30 miles (110 km. to 48 km.) per hour before it gets to the second signal which says "prepare to stop at next signal." The local train that is running at slow speed can thus close in. Between Bryn Mawr and Overbrook, on our Pennsylvania line, we have a 1 per cent down grade and it takes a train going 70 miles (110 km.) an hour a mile (1.6 km.) to stop. The signals are located 3,000 to 3,500 ft. (910 to 1,070 m.) apart, which gives us a 6,000 or 7,000 ft. (1,800 to 2,100 m.) breaking distance using the three-block indication down the hill. Uphill we use the two-block indication. So the local trains instead of being stopped by the stop signals at the long blocks, have short blocks so that they can keep moving. The fast trains can run at speed and still have ample warning to stop before they reach the danger point. The system has caused much discussion in the Railway Signal Association for the last 10 years and I suppose it will continue to do so, but it does not make much difference as long as people are beginning to use it. The cross-overs between tracks are of different lengths. The four-track tunk lines are installing 15 and 20 cross-overs from 300 to 360 ft. (91 to 110 m.) long. You can ride around them without knowing it at 50 miles (80 km.) an hour, cross from one track to the other and back again.

One of our big western railroad men told me of a trip he made from Pittsburgh to New York and he said they never left the straight track all the way through. He said he did not know why we wanted these long cross-overs because they just kept on the one track from Pittsburgh to New York. I looked up the schedule and showed him he crossed over 12 times.

We limit the speed of the trains to 30 miles (48 km.) over the long cross-overs, and to 15 miles (24 km.) per hour over short cross-overs, so we give them a slow speed signal. The signal also indicates whether the next one is set at clear or stop. If the train is going over a short cross-over or against traffic or into a yard, or to close up against a train so that other cars may be coupled, the engineer gets the low speed signal diagonal, which means "proceed at low speed prepared to stop." If on the other hand the train is going over a short cross-over with traffic and the track is clear, the engineer gets the low speed signal vertical, which means "proceed at 15 miles (24 km.) per hour." The signals indicate three primary speeds:

1. Proceed at the authorized speed, the limit of which is 70 miles (113 km.) per hour on our line.

2. Proceed at medium speed, 30 miles (48 km.) per hour.

3. Low speed, 15 miles (24 km.), per hour. In the proceed position they indicate the track is clear. in the 45 degree position, the signals indicate to the engineermen that the next signal is against them, and while they can proceed at the indicated speed at that point, they must be prepared to stop at the next signal. In manually controlled block territory where the trains are blocked by signal men located in signal cabins, the blocks generally are two and possibly three miles (3.2 to 4.8 km.) long and freight trains are permitted to follow freights into these blocks. For that purpose we have what we call a distant permissive signal which shows two horizontal green lights instead of one, with position light signal this is shown by the indications in the lower quadrant. The arm pointing down is a signal by which a man is told that the block is occupied but he may enter it and proceed with caution. In the automatic territory if the signal is at stop, the train is permitted to stop and then proceed with caution, expecting to find a train ahead and an open switch or a broken rail. That is indicated by the light on the mast below the horizontal arm. Those are the principal indications. One or two of them I rather feel can be dispensed with, and eventually the railroads may come to a uniform two-arm system, in which the second arm at 45 degrees indicates you can proceed at low speed prepared to stop. The second arm vertical indicates proceed at medium speed, and the top arm as I have indicated above. With this scheme we would always have two lights on each signal—never more than two lights—and if only one light is lit it is an indication of an improperly displayed signal. I think it will probably be fifteen or twenty years before we get around to it, but I believe it is coming. The roads that use one light are coming to the two-light system and the roads that use three lights may come to the two-light system.

The first power operated semaphore-arm signal was operated by compressed air and actuated by electricity, then came the direct current electric motor and finally the alternating current electric motor. A three-arm three-position interlocking signal costs between eight and nine hundred dollars, and when you have got thirty or forty thousand signals on the road it is somewhat expensive. I think our installation has probably cost us in the neighborhood of twenty-two or twenty-three million dollars, and it costs us over a million dollars a year to operate and maintain it. We generally get a million and one-half dollars and we use a little bit on the side, but it takes pretty nearly all of that to maintain and operate the signals. So it is not a small question by any means.

While the semaphore arm is of great value in daylight, we have had to resort to colored lights at night to indicate the position of the arm. The generally accepted practice in the United States in use by the majority of the roads is to use green for clear, corresponding to the vertical position of the arm, yellow for caution and red for stop. The roads are all coming to it. In the old system where the white light gave a clear signal, a broken red lens would indicate clear when it should be stop. I think it will only be a few years before all the roads will use green for clear and yellow for caution. The system changes as you all know, twice a day—semaphore arm in the day and colored lights at night. There is not enough daylight to see the arm at twilight and too much daylight to see the light well.

The light signal has been used for years on trolley lines. It was generally a lamp with a lens before it, which you could see 200 or 300 ft. (61 to 91 m.) away, and for a long time no headway was made in developing long range. I suppose the Pennsylvania line was the pioneer in developing a light signal. We had in Washington, and other roads had it too, a signal that had a moving lens in front of it. It was finally decided that that was not necessary and that we should simply shift the lights, and we developed a signal that was considered pretty good six or eight years ago; it could be seen 500 or 600 ft. (152 or 183 m.) in daylight. We have them still in Manhattan Transfer and in the terminal area and throughout the tunnels and they are mighty good signals in the dark. The Interborough has them in the tunnels, and they are a mighty fine signal for that purpose where it is semi-dark. During the last two or three years a great deal of progress has been made in getting long range with the colored light signal.

In 1912 or 1913 Dr. William Churchill was employed by some of the western railroads on the headlamp problem, and I don't think I am divulging any trade secrets when I say that he could get a very nice position light signal without any lights at all by putting a mirror back of a lens, and the reflection from the beam of headlight gave a very handsome signal two or three thousand feet away—showing that only a small light source was necessary. We decided that we could make a signal with rows of lights lighted up that would answer all the purposes and still be economical. It was made a commercial proposition by the development of the concentrated filament high efficiency lamp. The whole secret of it is the fact that there is no colored glass to cut down the range and the fact that we get a point of light in such a perfect focus that we utilize practically all the light available.

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Printing Ink for Half-Tone Work

A QUESTION which is recommended to the attention of inventors is the production of a special printing ink for half tone work. There are various inks in use at present, some of which are reasonably good, but none of them show in all respects a complete adaptation of an ink to this class of work. In order to aid inventors in their researches, some points may be given to show in what this adaptation consists and also what are the defects in existing inks, as well as the characteristic qualities of the ink which is to be sought for. It is well known that the half tone plates have an etched surface produced by the use of a screen and corresponding to the light and dark places of the original. The hollow places of the plate retain the ink and determine its distribution on the print as lights and shadows. What may be called the adaptation of the ink consists in its proper distribution, so that the tones of the print correspond to the different tones of the plate. The imperfections observed in the present inks, and which are opposed to this adaptation, are to be imputed, first, to the fluidity of the ink; second, to its adhesive power; third, to the lack of uniformity in its opacity. In consequence, the three correctives necessary to remedy this state of affairs should tend to produce the following results:

1. A suitable and constant fluidity. 2. An absolutely regular distribution of the coloring particles in their fluid container. 3. An adhesive power such that the amount of ink taken up by the plate and left on the print, should depend in the first place upon this fluidity, and in the second place upon the opacity of the ink. 4. A methodical proportionality in the distribution of the three elements which have a mutual effect upon each other. In fact, in order to obtain the best results, the three qualities mentioned, both in their nature and relations, cannot be the same for the use of the ink with a large-mesh or a fine-mesh plate, nor on the other hand, when printing on a smooth or a rough surface paper. However, the requirements of printing have shown that the mesh of the screen or the plate is to concord with the roughness or smoothness of the paper, that is, the largest mesh is to be used for the roughest paper. Other points have been omitted from the present considerations, such as the variations in permeability of the paper and in its absorbent power, for the ideal would be to suppress them altogether, and in the manufacture of ink, all substances would be reduced to a minimum which have a tendency to stain the paper after the manner of oil stains. Besides, in researches upon ink, we can use as a basis a smooth surfaced and impermeable paper. For the above reasons, it appears that the best solution of the problem would be to make a standard ink whose fluidity and adhesive power can be modified according to a given scale, corresponding to the greater or less fineness of mesh of the screen.

The Use of Soap Films*

In Solving Torsion Problems

By A. A. Griffith, M. Eng., and G. I. Taylor, M. A.

THE equations which represent the torsion of an elastic bar of any uniform cross section are of exactly the same form as those which represent the displacement of a soap film, due to a slight pressure acting on its surface, the film being stretched over a hole in a flat plate, of the same shape as the cross section of the bar. Advantage may be taken of the analogy to find the stresses and torsional stiffness of a twisted bar or shaft of any cross section whatever, by making appropriate measurements of soap films.

When shafts or beams of uniform cross section, other than circular shafts, either solid or having concentric circular holes, the initially plane section at right angles to the axis of torsion is distorted into a curved surface and the stresses and strains set up in the bar cannot be calculated until the shape of this curved surface has been found.

A simple method of determining these stresses would be of the very greatest assistance in general engineering work, and even more so in the many fresh problems which have to be dealt with in aeronautical calculations. In the very complex sections which occur in this work, such as those of airscrew blades, and the many forms of spars and struts, etc., used, it is of the highest importance that correct knowledge should be available and therefore the authors have carried out work at the Royal Aircraft Factory, Farnborough, with a view to solving the problem by means of a simple experimental method. The following is a very brief description of the method which has been developed.

A hole is cut, in a thin plate, of the section required to be investigated, and a circular hole of a predetermined diameter is cut alongside it. The plate is placed in a box and soap films are stretched across the holes. The films are blown out slightly by reducing the air pressure on one side of them. By making suitable measurments of the shape of the resulting film surfaces, as will be explained later, it is possible to find the stresses in a bar of the given section, in terms of the stresses in a circular bar of the same diameter as the circular hole, when the two bars are twisted through the same angle per unit length. It is equally easy, by means of other measurements, to find the ratio of the torques which must be applied to the two bars, in order to produce the same twist in each. It will readily be seen that by this means the most complicated sections can be dealt with.

Experimental Methods.—In order that full advantage may be taken of the information on torsion which soap films are capable of furnishing, apparatus is required with which three kinds of measurements can be made, namely: (*a*) Measurements of the inclination of the film to the plane of the plate at any point, for the determination of stresses. (*b*) Determination of the contour lines of the film. (*c*) Comparison of the displaced volume of the test film and circular standard for finding the coreresponding torque ratio.

(*a*) For this purpose optical reflection methods naturally suggest themselves. In the apparatus used by the authors the image of an electric lamp filament is viewed in the film in such a way that the reflected ray is coincident with the incident one, so that their common direction gives the inclination of the normal to the surface of the film. This experiment may conveniently be referred to as the measurement of angles by auto-collimation.

(*b*) For mapping contour lines, a steel needle point, moistened with soap solution, is arranged to move about over the plate carrying the film, its distance therefrom being adjustable by means of a micrometer screw. The point is made to approach the film till the distortion of the image in the latter shows that contact has occurred. This method of mapping contours will be referred to as the "spherometer" method.

(*c*) The most obvious way of measuring the displaced volume of the films is to blow them up by running a known volume of water, or, preferably, soap solution, into the apparatus from a pipette or burette.

Description of Apparatus.—In the apparatus used by the authors, the films are formed on holes cut to the required shapes in flat aluminium plates, of No. 18 S.W.G. thickness. The plates are held in a horizontal position during the experiment, and the edges of the holes are chamfered off on the under side, to an angle of about 45 degrees, in order to fix the plane of the boundary.

The apparatus is shown in Fig. 1. The test-plate is clamped between the two halves of the cast iron box A. The lower part of this box takes the form of a shallow tray ¼ in. deep, blackened inside and supported on levelling screws, while the upper portion is simply a square frame carrying the clamping studs, and enamelled white inside. A three-way cock communicates with the former and a plain tube with the latter. The film shown in the photograph represents a section of an airscrew blade. It will be noticed that a black spot has commenced to form at the top of the bubble.

The spherometer apparatus consists of a screw B, of

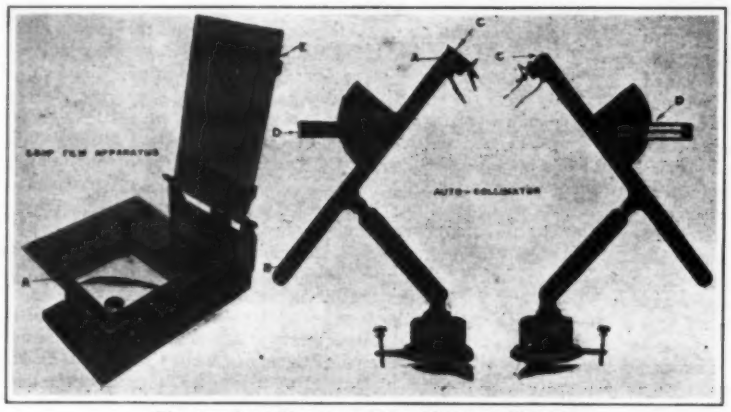

Fig. 1. Soap film apparatus and auto-collimator

1 mm. pitch, passing through a hole in a sheet of plate glass ⅛ in. thick and sufficiently large to cover the box in any possible position. It slides about on the flat upper face of the latter. The lower end of the screw carries a hard steel point C, tapering about 1 in 4, and its divided head moves beside a fixed vertical scale. Fixed above the screw and in its center line is the steel recording point D. The record is made on a sheet of paper fixed to the board E, which can swing about a horizontal axis at the same height as D. To mark any position of the screw, it is merely necessary to prick a dot on the paper by bringing it down on the recording point.

In the auto-collimator—Fig. 1—light from the straight filament of the 2-volt bulb A is reflected from the surface of the film through a V-nick B and a pin-hole eye-piece C,

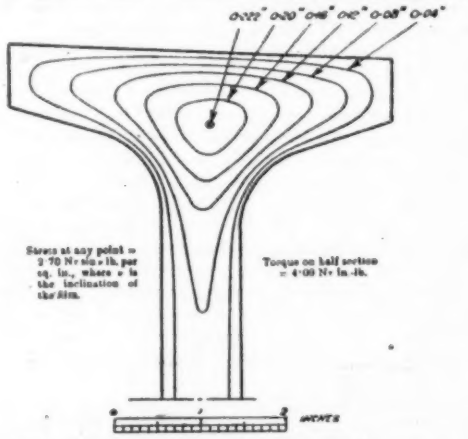
0·01" 0·02" 0·03" 0·04" 0·05" 0·06"
Stress at any point = 2·70 N·sin ϑ lb. per sq. in., where ϑ is the inclination of the film.
Torque on half section = 4·09 N· In.-lb.
INCHES

Fig. 2. Stress contour lines in a wooden spar

placed close to the lamp and shaded from direct light by a small screen. The inclinometer D, which measures the angle which the optical axis makes with the vertical, consists of a spirit level, of 6 ft. radius, fixed to an arm which moves over a quadrant graduated in degrees. The apparatus is mounted by means of a stiff-jointed link, on a tripod stand weighted with lead. Fine adjustment of angle is made with a screw.

In the case of the spherometer, the point, previously moistened with fresh solution, is set to a given height and made to touch the film at a number of positions, which are marked on the paper. This is repeated for as many contour lines as may be required. The plate need not be levelled. A contour map taken in this way is to be seen on the board, Fig. 1.

Usually, the use of the auto-collimator is confined to the determination of inclinations at given points on the boundary, which are marked by scratches on the plate. It is better for stress measurements than the contour line method, since it gives the inclination directly, whereas in the other case the latter can only be found by a graphical differentiation. The use of the optical method may be extended to the finding of inclinations at points other than those on the boundary, with the help of the spherometer in the following manner. The outline of the experimental hole is marked on the paper by means of the recording point, and the position of the point for which the stress is desired is added. The glass plate is adjusted until the recording point coincides with it. The needle is screwed down till it just touches the film, and its height is noted. It is then screwed back till the film breaks away and finally brought down again to within one or two thousandths of an inch of its former height. The auto-collimator is now adjusted till the image of the filament is seen in the film just below the needle-point. The reading of the inclinometer then gives the required angle.

The average error is 0.89 per cent. In four of eight cases considered the error is greater than 1 per cent, and in three of these it is negative. One may conclude that the probable error is somewhat greater than it is for the stress measurements, and that it tends to be negative. Its upper limit is probably not much in excess of 2 per cent.

As confirmation of the correctness of solutions of the torsion problem obtained by the soap film method, some experiments on wooden beams may be cited. In the first of these, a walnut plank was shaped so that its section was exactly the same as the hole in one of the test-plates, which represented a section of an airscrew blade, of fineness ratio 10.55, having its thickest part about a third of the way from the leading edge. The value of the modulus of rigidity, N, was found by performing a torsion test on this plank, using the expression for the torque given by a soap-film experiment on the plate which was used in shaping the plank. N was found to be 0.1355×10^6 lb. per square inch. Five circular rods were then cut from the plank and their rigidities were measured. The mean value of N found in this way was 0.1387×10^6, a difference of only 2.3 per cent.

When contour lines have been mapped the torque may be found from them by integration. If the graphical work is carefully done the value found in this way is rather more accurate than the one obtained by the volumetric method. Contours may also be used to find stresses by differentiation, that is, by measuring the distance apart of the neighboring contour lines; but here the comparison is decidedly in favor of the direct process, owing to the difficulties inseparable from graphical differentiation. The contour map is, nevertheless, a very useful means of showing the general nature of the stress distribution throughout the section in a clear and compact manner. The highly stressed parts show many lines bunched together, while few traverse the regions of low stress, and the direction of the resultant stress is shown by that of the contours at every point of the section. Furthermore, the map solves the torsion problem, not only for the boundary, but also for every section having the same shape as a contour line.

Experimental Results.—The two examples which follow serve to illustrate the use of the soap-film apparatus in solving typical problems in design:

(1) It is well known that the stress at a sharp internal corner of a twisted bar is infinite, or rather would be infinite if the elastic equations did not cease to hold when the stress becomes very high. If the internal corner is rounded off the stress is reduced; but so far no method has been devised by which the amount of reduction in strain due to a given amount of rounding can be estimated. This problem has been solved by the use of soap films.

An L-shaped hole was cut in a plate. Its arms were 5 in. long by 1 in. wide, and small pieces of sheet metal were fixed at each end, perpendicular to the shape of the hole, so as to form normal septa. The section was then practically equivalent to an angle with arms of infinite length. The radius in the internal corner was enlarged step by step, observations of the maximum inclination at the internal corner being taken on each occasion.

The inclination of the film at a point 3.5 in. from the

*The Institution of Mechanical Engineers. From *The Engineer*.

corner was also observed, and was taken to represent the mean boundary stress in the arm, which is the same as the boundary stress at a point from the corner. The ratio of the maximum stress at the internal corner to the mean stress in the arm was tabulated for each radius on the internal corner.

The results are given in Table I.:

TABLE I.—*Showing the Effect of Rounding the Internal Corner on the Strength of a twisted L-shaped Angle Beam.*

Radius of internal corner	Ratio: Maximum stress / Stress in arm
Inches	
0.10	1.890
0.20	1.540
0.30	1.480
0.20	1.445
0.50	1.430
0.60	1.420
0.70	1.415
0.80	1.416
1.00	1.422
1.50	1.500
2.00	1.660

It will be seen that the maximum stress in the internal corner does not begin to increase to any great extent till the radius of the corner becomes less than one-fifth of the thickness of the arms. A curious point which will be noticed in connection with the table is the minimum value of the ratio of the maximum stress to the stress in the arm which occurs when the radius of the corner is about 0.7 of the thickness of the arm.

A further experiment was made to determine the extent of the region of high stress in angle iron with the radius at the corner one-tenth the thickness of the arm. For this purpose contour lines were mapped, and from these the slope of the bubble was found at a number of points on the line of symmetry of the angle iron. Hence the stresses at these points were deduced.

It was found that the stress falls off so rapidly that its maximum value is to all intents and purposes a matter of no importance, if the material is capable of yielding. If the material is brittle and not ductile a crack would, of course, start at the point of maximum stress and penetrate the section.

(2) The diagram shown in Fig. 2, which represents the half section of a wooden wing spar, is a good example of the contour line method. The close grouping of the lines near the internal radii, denoting high stress, is immediately evident. The projecting parts of the flange are lightly stressed and contribute little to the torsional stiffness. The stress at the middle of the upper face is, however, considerable, being, in fact, next in order of magnitude below that in the radii. The stress near the middle of the webb is practically constant and equal to that in a very long rectangular section of the same thickness under the same twist.

A further point of interest is that the "unstressed fiber" is very near the center of the largest circle which can be inscribed in the section. It will also be observed that the three points of greatest stress are almost coincident with the points of contact of the circle. The maximum stress is about 1.89 times the mean boundary stress.

The figures given below the diagram for the values of the stress and torque on the section fully confirm the generally accepted notions regarding the extreme weakness of I-beams in torsion.

General Deductions from the Soap Film Analogy.—One of the greatest advantages of considering the torsion problem from the soap film standpoint arises from the circumstance that it is very much easier to form a mental picture of a soap bubble than it is to visualize the complicated system of shear-strains in a twisted bar. It cannot be too strongly urged that the surest way of forming a clear idea of the nature of the torsion problem is to blow a few soap films on boundaries of various shapes. This can be done with the simplest of apparatus; the holes may be cut in plates of thin sheet metal, which can be luted on to the top of a biscuit tin with vaseline or soft soap. To blow the films up it is only necessary to bore a hole in the bottom of the tin and stand it in a vessel containing water. Two sections may readily be compared by cutting them in the same plate. A simple way of estimating inclinations is to view the image of the eye in the film and adjust the arm of a clinograph so that it lies along the line of sight.

With the aid of simple apparatus of this kind the truth of theorems, such as those contained in the following list, may be readily demonstrated.

(*a*) The stress distribution—and therefore the torque—for any section is independent of the axis of twist. This is easily seen, since the shape of the soap film is completely determined by the boundary and the value of $\frac{48}{p}$.

Hence the torque on a number of bars clamped together at their ends may be found by adding the separate torques which would be necessary to twist each through the same angle. This, as in other cases, applies to torque only. It will be realized that in practice there will be bending stresses which must be taken account of in the usual way.

(*b*) Any addition of material to a section must increase the torque, and *vice versa*, so long as the distribution of material in the original section is unaltered.

(*c*) Any cut made in a section, whether it decreases the area or not, must decrease the torque.

(*d*) The stress at any point of the boundary of a section is never less than the boundary stress in a circular bar under the same twist, whose radius is equal to that of the circle inscribed in the section, which touches the boundary at the point in question.

More generally, if one section lie entirely inside another, so as to touch it at two or more points, the stresses in the inner figure are less than those in the outer one at the points of contact; if the two figures are approximately congruent in the neighborhood of the points of contact, the difference between the stresses is small. The maximum stress in a section is not greater than $2aN\tau$, where a is the radius of the largest inscribed circle, unless the boundary is concave, that is, re-entrant.

(*e*) If a concave part of the boundary approximates to a sharp corner, the stress at this point may be very high, and if the curvature is infinite then the stress is also theoretically infinite, whatever be the situation of the corner with respect to the rest of the section. Actually, of course, if the material is ductile, we can only deduce that the stresses at such a corner are above the elastic limit.

(*f*) It is a consequence of (*e*) that it does not necessarily follow that the making of a cut in a section will reduce its strength, whether material is removed or not. As an example of this, one may quote the case of an angle iron in which the internal corner is quite sharp. It is well known in practice that this will often fracture. It may be strengthened, however, by reducing the section, planing out a semi-circular groove at the root of the angle iron.

(*g*) There can be no discontinuous changes of stress anywhere in a section, excepting only those parts of the boundary where the curvature is infinite—concave or convex sharp corners.

(*h*) The maximum stress occurs at or near one of the points of contact of the largest inscribed circle, and not, in general, at the point of the boundary nearest the centroid, as has been hitherto assumed. An exception may occur if, at some other part of the boundary, the curvature is—algebraically—considerably less—that is, the boundary is more concave—than it is at this point.

(*i*) If a section is long compared with its greatest thickness be bent so that its area and the length of its median line are unchanged, its torque will not be greatly changed thereby. For instance, the torsional stiffness of a metal plate is practically unaltered by folding or rolling it up into the form of an L or a split tube. Soap-film experiments show, in fact, that there is a diminution of less than 5 per cent when the inner radius of the boundary is not less than the thickness at the bend.

(*j*) The "unstressed fiber," which is situated at the point corresponding with the maximum ordinate of the soap film, is near the center of the largest circle which can be inscribed in the section.

In general, the inscribed circle has a maximum value wherever it touches the boundary at more than two points, and there is usually an unstressed fiber near the center of each of these circles. Between each pair of maximum ordinates on the soap film, however, there is a "minimax" point, which is near the center of the corresponding minimum inscribed circle. This fiber in the bar is also unstressed.

(*k*) The "lines of shearing stress" round the unstressed fibers of the first sort are initially ellipses, and round those of the second sort hyperbolæ, from which shapes they gradually approximate to that of the boundary. Notions of this sort are useful in practice, because it is possible, with their help, to sketch in the general nature of the lines of shearing stress for any section. The rest of the paper is devoted to the discussion of approximate formulæ for torques and stresses, and concludes with a mathematical appendix. Those who desire to follow the matter further will do well to refer to the original.

On Severe Winters

A "CHARACTER-NUMBER" to express the degree of severity of any winter is obtained in the following way: The mean temperature in degrees Centigrade for each day of November, December and January is taken; of these the negative values are selected and added together; the result, viz. the sum of the negative daily means, is the character-number. Of the last 150 winters in Berlin, 24 are classified as "very severe." The most severe was the winter of 1829-30, and that of 1788-9 was almost as severe. The winter of 1916-7 comes out only as a moderately severe one. Since the middle of the nineteenth century the number of very severe winters has been much reduced; in the period 1788 to 1845 that number was great, namely 17. A very severe Berlin winter is associated with the presence of a prolonged snow-covering, and a westerly position of the continental high-pressure system.—Note in Sci. Absts. on an article by G. HELLMANN, in *Preuss. Akad. Wiss.*

Correspondence

[*The editors are not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.*]

Use of the Heliograph

Editor SCIENTIFIC AMERICAN SUPPLEMENT:

On page 36 of the SCIENTIFIC AMERICAN SUPPLEMENT, dated July 21, 1917, you published an article on the use of the heliograph by the Forest Service in fire protection work, and described the use of the Myer Code in that connection. The usefulness of the heliograph by the Forest Service has been almost nullified in the past by the practical difficulties involved in learning and memorizing this perplexing and arbitrary code, especially since our lookouts and patrolman are on duty only for a few months during the summer and do not, therefore, have the opportunity for constant practice. To obviate these difficulties, Forest Ranger S. A. Boulden, of the Cleveland National Forest, has developed a new code which is a marvel of simplicity, can be learned by anyone at a glance, and, if one forgets it, he can easily figure out the signal for any letter in a few seconds.

By the Boulden Code the alphabet is divided into five series, each, except the last, containing six letters, the several series thus beginning with the letters A, G, M, S, and Y. These series letters, with a few abbreviations, then constitute all that must be memorized. Any given letter is represented in code by 1, 2, 3, 4, or 5 long flashes, corresponding to the number of the series, followed by short flashes corresponding to the relative position of the required letter in the given series; thus, "A" is 1 long, 1 short; "B" 1 long, 2 short; "O" 3 long, 3 short, etc. It is, however, unnecessary to memorize the code for each letter since, when sending the letter "O," for instance, one merely follows the 3 long flashes, as given, in the order A, G, *M*, then, as the short flashes begin, repeats the alphabet one letter at a time for each flash given, beginning with the series initial—M, N, *O*. The same mental process is followed in sending.

The Boulden Code requires few, if any, more flashes for a given message than does the Myer, since the greatest number of flashes for any single letter in the former is ten, and in the latter, eight. Furthermore, this code has been found to be speedier, since there is never any necessity for repeating due to a misunderstanding caused by running two letters together. In the Myer Code, for instance, the letter "A" is represented by 22, "T" by 2. In sending the word "at," haste or inexperience often shortens the space between the two letters, so that it is read 222, the code signal for the letter "D." With the Boulden Code, there can be no possibility of such a mistake, since one or more long flashes must always begin a new letter and intervene between the last short flash of the preceding letter. The only exception to this is in case two or more consecutive letters are used from the same series, in which case the long flashes may be given only for the first letter used from that series, and dispensed with for the other letters immediately following in the same series.

The code I have described has been widely adopted by the Forest Service and has revolutionized the use of the heliograph in connection with our work of forest fire detection and prevention.

M. R. TILLOTSON,
Escondids, Cal. Forest Supervisor.

Gravitation

Editor SCIENTIFIC AMERICAN SUPPLEMENT:

Modern views hold that a molecule is composed of a number of electrons held in stable orbital motion by the attraction of a sphere of positive electrification.

We can simplify matter and also explain gravitation by assuming that a molecule is a small void or vacuum in the ether maintained by the vibration of electrons.

Every molecule in the universe would then tend to intercept and absorb or neutralize a small percentage of the pulses from every other molecule leaving an unbalanced thrust against the ether on the far side directly proportional to the product of the masses and inversely proportional to the square of the distance between.

If this explanation be valid, gravitation is due to ETHER RESISTING COMPRESSION.

F. A. LIPPINCOTT.
Sharon, Pa.

Contact Insecticides*

Physical Properties Governing Their Efficacy

By William Moore, Head of Section of Research in Economic Zoology, and S. A. Graham, Assistant in Entomology, Minnesota Agricultural Experiment Station

It was considered by Shafer (*16*)[1] that the vapor of contact insecticides such as kerosene, gasoline, creolin, and pyrenthrum were responsible for the death of insects to which these materials were applied. It was therefore assumed as a working basis that the volatility of organic compounds, which has previously been shown to be an index of the toxicity of their vapors to insects (*11, 12*), would also be an index of the toxicity of these compounds when used as contact sprays. In working with insect eggs (*14*), however, it was found that materials not sufficiently volatile to kill insects or their eggs by their vapor within a reasonable length of time, were among the most effective materials when applied to the eggs as liquids. Further studies in which different fractions of kerosene were used (*13*) revealed the fact that the least volatile fractions were the most effective as contact insecticides, while they failed to kill insects which were exposed only to their vapor.

With these results in mind it was considered advisable to determine the physical properties governing the entrance into the insect of a contact insecticide, and wherein this differs from the penetration of the vapor.

WETTING AND SPREADING OF THE INSECTICIDE

It is common observation that when some contact insecticides strike an insect they form into round droplets which roll off the body, while others spread out, forming a film over the insect. This phenomenon of the spreading out of the insecticide over the body has been often termed "wetting" or "spreading" and is often confused with the wetting and spreading of the insecticide over the surface of the leaves sprayed, the terms "wetting" and "spreading" being used synonymously. Vermorel and Dantony (*18, 19, 20*), Lefroy (*5*), and more recently Cooper and Nuttall (*2*) have studied the physical principles governing the wetting and spreading of contact insecticides and have endeavored to devise means by which these important properties may be easily measured. In all of these papers the authors have failed to distinguish between wetting and spreading. In this paper a distinction will be drawn between these two terms. If a liquid is placed upon a solid, and there is a specific attraction between the two, they will come into actual contact. The slight chemical affinity exhibited between the two substances is what is denoted as wetting, or adhesion between the liquid and the solid. For example, if a drop of mercury is placed upon glass, there is no specific attraction between the two, owing to the film of moisture and air on the surface of the glass (*3, p. 176*). Hence, the mercury is said not to wet the glass, and there is no adhesion between the two. By boiling the mercury in a glass tube and thus expelling the moisture and air between the mercury and the glass, it is found that there is an actual weeting of the glass by the mercury, as is indicated by adhesion.

If a liquid is brought into contact with a solid and wetting takes place, the spreading of the drop into a thin film may or may not occur. The law governing spreading has been carefully explained by Cooper and Nuttall (*2*). They find that if the surface tension of the substance upon which the spray is placed is greater than the surface tension of the spray plus the surface tension at their interface (interfacial tension), the liquid will spread. Otherwise there will be no spreading. Bigelow and Hunter (*1*) have given a very much simpler explanation of the whole matter. They consider (*p. 377—38?*) that if a liquid is in contact with a solid—that is, actually wetting the solid—two forces are at work.

First, the cohesion between the like particles of the liquid which, in the surface layer is denoted by the phrase, "surface tension," and second, the adhesion between the liquid and the walls [solid].

Thus, if adhesion to the solid is stronger than the cohesion of the liquid, the liquid will spread over the solid. The same law applies when two liquids are in contact. The following experiment will serve as an example. If a filter paper is soaked in water and spread out flat on a glass plate, a drop of kerosene on this wet paper will quickly spread into a thin film. In this case the adhesion between the water and the kerosene is greater than the cohesion of the kerosene. On the other hand, if the filter paper is soaked in kerosene and a drop of water placed upon it, the water does not spread out into a thin layer. In this case the cohesion of the water is greater than the adhesion between the water and the kerosene, which is the same in both experiments. Thus, it is clear that there must be wetting before there can be spreading, but it does not necessarily follow that when there is wetting there must be spreading, for otherwise the water would have spread over the kerosene.

One other factor has a considerable influence on the spreading of an insecticide—namely, viscosity. Viscosity may be defined as "the internal friction of a liquid." Although the viscosity does not influence the ultimate extent to which a liquid may spread, it does have a very decided influence on the rate of spread. It is possible that a liquid may be so viscous that the rate of spread may be reduced to such an extent as to make it valueless as an insecticide.

From the foregoing statements it is apparent that when a spray strikes an insect, if there is a chemical affinity between the insecticide and the chitin which forms the outer covering of the insect, wetting will take place and the insecticide will adhere. If the cohesion of the spray is less than the adhesion between the chitin and the spray, then the liquid will spread over the body of the insect. The rate at which this spreading will take place is governed by the viscosity of the liquid. If the cohesion is greater than adhesion, the spray will form into droplets which tend to roll off. The same result is obtained when the spray does not wet the insect. It is apparent therefore that in a contact insecticide it is important not only that the liquid should wet the chitin, but also that the adhesion of the liquid to the chitin should be greater than the cohesion of the liquid.

RELATION BETWEEN SPREADING AND CAPILLARITY

The rise of a liquid in a capillary tube is governed by the same laws as the spreading of a liquid over the surface of a solid. First, unless the liquid has a specific attraction for the material of which the tube is composed (wetting), there can be no capillary rise. Second, unless the adhesion between the liquid and the walls of the tube is greater than the cohesion of the liquid, there can be no capillary rise. This is well shown by Bigelow and Hunter's (*1*) studies of the rise of water in capillary tubes of different materials. In their experiments the cohesion of water remained the same, but owing to different degrees of adhesion between the water and the walls of the capillary tubes, variations were noted in the height to which the liquid rose in tubes of different materials. It is evident, therefore, that since the tracheæ are lined with chitin, similar to the covering of the body wall, insecticides which will spread over the body will also penetrate the tracheæ by capillarity, while those insecticides which do not spread over the insect, even though they may come in contact with a spiracle, will not be able to penetrate the tracheæ.

Contact insecticides may therefore be divided roughly into two groups: First, those which wet the insect and, owing to greater adhesion than cohesion, are able to spread over the surface of the body and pass up the tracheæ by capillarity. Second, those which wet the insect, but which, owing to a higher cohesion than adhesion, are able neither to spread over the surface nor to gain entrance into the tracheæ by capillarity.

PENETRATION OF LIQUIDS INTO TRACHEÆ

From the results of Cooper and Nuttall (*2*) it would appear necessary to make determination of the surface tension of the insecticide, the surface tension of the chitin, and the surface tension at the interface of the chitin and the insecticide before it could be determined whether or not the liquid would spread over the body and penetrate the tracheæ. From the results of Bigelow and Hunter (*1*), however, the capillary rise in a tube really determines whether the adhesion between the liquid and the solid is greater than the cohesion of the liquid, or, in other words, is a means of determining whether the surface tension of the solid is greater than the surface tension at the interface between the solid and the liquid plus the surface tension of the liquid. By placing an insect in the insecticide to be studied for a short period and then dissecting it, it is possible to determine whether or not the insecticide has penetrated the tracheæ, and approximately how far. These results give an index of the spreading ability of the different materials.

The cockroach (*Blatella germanica* L.) was used in the following experiments for determining the penetration of insecticides into the tracheæ. The results were checked over with certain of the compounds using the wax-moth larvæ (*Galleria mellonella*), the larvæ of the Indian meal moth (*Plodia interpunctella* Hbn.), and certain aphids. The methods of procedure were as follows: The liquid to be tested was stained with Sudan III or trypan-blue, both of which are colloids, and therefore will not pass through a semipermeable membrane. The cockroach was placed into the liquid and allowed to remain for from 15 minutes to 2 hours, depending upon the viscosity of the liquid. After a sufficient time had been allowed for the liquid to penetrate, the cockroach was removed and opened on the ventral side. The tracheæ which were penetrated by the material stood out either red or blue, and it was very easy to determine the extent of the penetration.

It was found that aqueous solutions other than soap solutions do not penetrate the tracheæ. It was interesting to note that both nicotine and absolute alcohol are able to penetrate the tracheæ, but when greatly diluted with water they are no longer able to enter. Those substances which in an aqueous solution exhibit surface viscosity, such as saponin, gelatin and casein, do not penetrate the tracheæ. Those materials have frequently been employed in preparing emulsions (*4, 20, 21*). Compounds which are soluble in ether or are capable of dissolving fats or oils are able to spread over the body of the cockroach and penetrate the tracheæ. Such substances as acetic acid, furfurol, and nicotine are not particularly good fat solvents, and it may be noted that they did not penetrate any great distance into the tracheæ. Compounds with a high viscosity, such as lubricating oil, failed to penetrate far into the tracheæ; but if these viscid substances had been given a longer time they would undoubtedly have penetrated much farther. Some soap solutions, such as ivory, gel at room temperatures in dilutions ordinarily used in spraying (1:150 or 200), and are therefore unable to penetrate to any great extent. The penetration of such a soap solution is increased when its cohesion is reduced by raising the temperature of the solution. Soft soap and yellow soap were liquid at the same dilution and penetrated better than Ivory soap, while Castile soap, manufactured from the liquid oleic acid, penetrates very well.

According to Morgulis (*15*) the exact chemical composition of chitin is still questionable. From our results its composition must be such that it is easily wetted by oils and oil solvents, or perhaps the surface of the chitin itself contains or is coated with an oily or a fatty substance. These results can not be applied to all insects, as some have special coverings of wax over the chitin. The spreading of sprays on such insects can, however, be determined by our methods with little trouble.

RELATION OF VISCOSITY AND VOLATILITY TO THE PENETRATION OF THE TRACHEÆ

The foregoing results have been primarily concerned with the pure materials. Inasmuch as the pure materials are seldom applied in actual practice, the question arises as to what takes place, when an emulsion of an oil is used in spraying. By placing drops of the emulsion on the wings, and also on the bodies of cockroaches, it was found that the oil droplets were completely surrounded by the emulsifier and did not come in contact with the body of the insect. The ability of such a spray to adhere to the insect, to spread over the body, and to penetrate the tracheæ depends, therefore, on the character of the emulsifier and not on the emulsified oil. Three distinct types of emulsions were noted: First, emulsions made with gelatin or saponin formed a round drop and tended to roll off the insect, just as did pure aqueous solutions of these materials. Second, emulsions made with Castile or soft soap adhered to the insects and spread over the body, penetrated the tracheæ, carrying the emulsified oil with them. Third, emulsions made with using Ivory soap adhered to the body of the insect; but, owing to the high cohesion of the liquid, spread very slowly. In the third case it was noticed that in a comparatively short time, depending upon the temperature and humidity of the surrounding atmosphere, the water evaporated and the emulsion broke down, after which the oil spread over the surface of the body, penetrating the tracheæ. The length of time required for the breaking of the emulsion was from 5 to 30 minutes. If the oil was rather volatile, it would evaporate before it succeeded in penetrating

*From the *Journal of Agricultural Research*.

[1]Reference is made by number (italic) to "Literature cited," at end of paper.

the tracheæ. By spraying a number of insects it was determined that oils more volatile than xylene were too volatile to succeed in penetrating the tracheæ in large enough quantities to result in the death of the insect. On the other hand, the oil may be so viscous that, even after the breaking of the emulsion, it is unable to spread over the body and enter the tracheæ in a reasonable length of time. The viscosity of a number of oils was determined in terms of water by measuring the length of time required for 5 c. c. of the liquid to flow through a glass tube of small diameter arranged in the form of a stalagmometer.

By placing a small drop of oil on the wing of a cockroach and watching it under the miscroscope it was possible to divide the oils into four classes: (1) Those spreading rapidly, (2) those spreading slowly, (3) those spreading very slowly, and (4) those spreading so slowly as to preclude any possibility of their reaching the spiracles in a reasonable length of time.

PENETRATION OF THE INSECTICIDE INTO THE TISSUES

Shafer (*16*) has shown that contact insecticides, such as kerosene and others of a similar nature, are able to penetrate the tracheæ of an insect, but he considers that it is the vapor from these substances, which is responsible for the killing, inasmuch as the rate at which the liquid itself will pass through the chitin is too slow to account for the death of the insect. He dissolved Sudan III in kerosene to show the passage of the oil through the walls of the tracheæ. At the time of the death of the insect he could find no evidence of a red stain in the tissues, and it was not until the insect had been dead for a long time and the fat bodies had been partially dissolved that he could detect traces of the strain in the tissues. Sudan III, however, is a colloid, and would not be able to pass but very slowly through a semipermeable membrane such as chitin. Thus, the inability of the stain to pass through the chitin did not necessarily imply that the kerosene had not been able to penetrate into the tissues. If the experiment is repeated with picric acid instead of Sudan III, it is found that the tissues are very quickly stained yellow. There are, however, a number of objections to the use of a stain to indicate the passage of a liquid, as it is quite possible that the stain could penetrate by being absorbed by the walls of the tracheæ without any penetration of the oil. If a few pieces of chitin are placed in kerosene stained with picric acid, they are capable of absorbing practically all the stain from the oil. On the other hand, it is quite possible that the amount of the insecticide which might penetrate and kill the insect would be so small that the amount of stain carried with it could not be detected. Further, it would be impossible to determine the penetration of a vapor by a stain in the insecticide. Chemical tests for insecticides in the tissues in many cases would not be delicate enough for the certain detection of their presence or absence. Finally, after a number of trials, it was found that the best method was to use an indicator for dead tissues. Trypan blue is a water-soluble colloid which does not penetrate the living tissues, but is able to penetrate and stain dead tissues. This was selected as the most suitable indicator. Larvæ of the wax moth were used in these experiments. If a living, untreated larva is opened and the tissue covered with an aqueous solution of trypan blue for a period of two minutes and the stain then removed and the larva examined under water, it will be found that there are particles of the stain adhering along the midintestine, more or less on the silk glands, and along the nerve cord. This does not seem to be a true staining of the tissues, but rather the adherence of particles of the stain, which are difficult to remove by washing (adsorptions).

When an insect has been treated with an effective contact insecticide and opened and stained just before it dies, the tissues which have been killed are stained a deep blue, thus indicating the point of entrance of the poison. No effort was made in this work to determine which tissues were primarily effected by the chemicals. As a counter stain, to show to what extent the materials penetrated the tracheæ, Sudan III was used with the oils and resin with the aqueous solutions.

The insecticides may be divided into four different groups: (1) The nonvolatile insecticides which as liquids penetrate the tracheæ. (2) The volatile insecticides which are able to penetrate the tracheæ as liquids. (3) The volatile insecticides which only penetrate the tracheæ in vapor form. (4) The nonvolatile insecticides which decompose on contact with the insect, producing a vapor which is capable of entering the tracheæ. The results of experiments show that relatively nonvolatile oils pass through the walls of the tracheæ only where the liquid has penetrated.

Soap solutions are particularly interesting, since when a soap is dissolved in water it is hydrolyzed, some of the soap molecules reacting with the water to form sodium hydrate and the free fatty acid. This free fatty acid unites with the fatty acid of that portion of the soap which has not been hydrolyzed, forming a sol (*10*). Since the chitin is a semipermeable membrance, the sol is able to pass through but very slowly into the body of the insect. The sodium hydrate in the solution is no doubt the portion which accounts for death. Experimental evidence shows that solutions of soaps containing a large percentage of free alkali are more toxic than those which are practically neutral.

Volatile oils and acids show a blue staining along the walls of the tracheæ where the liquid has penetrated, and also blue blotches along the walls beyond this point. Examination of insects which have been treated for varying lengths of time show that the blue blotches caused by the vapor of the chemical appear more quickly than the blue caused by the penetration of the liquid itself, showing that the vapor is able to penetrate the walls of the tracheæ more quickly than the liquid. It might be noted here that these results are somewhat modified by the fact that the vapor is passing through somewhat thinner chitin than that through which the liquid must pass.

Aqueous solutions such as nicotine do not penetrate the tracheæ other than in the form of a vapor. The blue in this case occurs in blotches along the walls of the tracheæ. What was evidently a condensation of the vapor appeared in the larger tracheæ and the blue staining of the tissues was particularly strong at these points. This confirms the observations of McIndoo (*8*), who has shown by chemical means the condensation of nicotine within the tracheal tubes. When nicotine sulphate comes in contact with the body of the insect, it is slowly decomposed, with the formation of nicotine which enters as a vapor. Such a decomposition is no doubt the explanation of the results of Lovett (*6*), who found that leaves sprayed with nicotine sulphate even when dry are repellent and poisonous to insect larvæ, even though not taken internally.

To such aqueous solutions, which normally are not able to enter the tracheæ, the addition of soap increases their efficiency, as it enables the liquid to spread over the body and enter the spiracles. The addition of too much soap will somewhat decrease the efficiency of the spray, owing to increased cohesion. Some of the results obtained in the use of nicotine sulphate and fish-oil-soap sprays by Smith (*17*) are thus explained.

In general there was little evidence of penetration of the insecticides through the body wall. This does not necessarily mean that the compounds are not able to penetrate the chitin, but that they were unable to do so prior to their entrance by way of the tracheæ. Compounds which are readily soluble in water and readily diffuse in aqueous solutions were frequently found to have gained entrance through the anus and through the mouth. Alcohol, acetic acid, and sometimes soap showed such penetration. The more viscous compounds require very much longer to enter the insect than compounds with a low viscosity. Lime-sulphur differs from other contact insecticides in its action, but its action has been fully described by Shafer (*16*).

PENETRATION OF FUMIGANTS

Fumigants gain entrance into the insect by way of the tracheæ. In many cases what appeared as a condensation was noticed within the tracheæ and in such cases blue staining, indicating dead tissues, appeared at these points. These results explain why the volatility of organic compounds should be related to their toxicity (*12*). The more nearly the atmosphere is saturated with the vapor, the more likelihood there is of a condensation in the tracheæ. Even though there is no condensation, the same forces are at work. One of these forces is the tendency for the vapor to condense on coming in contact with the chitinous walls of the tracheæ. The other force is the tendency of the compound to re-evaporate from the tracheal walls. In the least volatile this tendency to re-evaporate is generally diminished, while in the more volatile compounds, in order to reduce this tendency to re-evaporate, very large quantities of the chemical must be present in the air. It is thus apparent that an insect may be killed with comparatively small doses of slightly volatile compounds, while it may require a much heavier dose of a more volatile material. The volatility of organic compounds is therefore, in general, an index of their ability to penetrate into the body of the insect, and inasmuch as the compound which can not penetrate will be unable to kill, it is apparent that the volatility is correlated with the toxicity. One notable exception mentioned in a previous paper (*12*) is that of Chlorpicrin, which in very minute quantities is able to kill the insect. In our experiments in tracing the penetration of fumigants it was noticed that this material was able to penetrate the walls of the tracheæ and kill the insect very quickly. This may be due to one of two factors: First, the extreme toxicity of chlorpicrin, or second, an abnormal power of penetration.

The following experiment throws light on this question. Acetic acid and benzene are of about the same volatility as chlorpicrin. On assuming, therefore, for the sake of the experiment, that their powers of penetration are equal, it was determined to test their comparative toxicity to insect tissues. Three living wax-moth larvæ were opened on the ventral side and spread out. One was treated directly with acetic acid, the second with benzene, and the third with chlorpicrin for a period of one-half minute. The chemicals were then quickly removed, and the tissues were washed with water and then treated with trypan blue. The larva treated with acetic acid showed a very intense blue-staining throughout the tissues. The larva treated with benzene showed but slight staining. The larva treated with chlorpicrin showed more staining than benzene but much less than that of acetic acid. Of the three compounds acetic acid was by far the most poisonous to the tissues. In actual fumigation, dipping, or spraying, the death of the insect occurs most quickly with chlorpicrin. This material, therefore, must owe its abnormal toxicity to its ability to be absorbed by the chitin and passed into the body. The reason for this high power of penetration of chitin by chlorpicrin will be the object of further study.

SUMMARY

From the general results reported in this paper it appears that the physical properties as well as the chemical properties have an important bearing upon the efficiency of the contact spray. Even though the spray may contain a very active poison, it will not be effective unless it conforms to certain physical requirements—that is, the ability to vaporize and penetrate in the form of a vapor or to spread over the insect and penetrate in the liquid form. The results reported by McClintock, Houghton, and Hamilton (*7*) show very clearly that this is true. The results in the use of quassia with or without soap as reported by McIndoo and Sievers (*9*) are another example, and it is a common observation that the addition of soap to nicotine sprays increases their efficiency. The following are some of the principles which must be kept in mind studying the effects of contact insecticides.

(1) Contact insecticides may be divided into two groups: (a) Those which spread over the body of the insect and penetrate the tracheæ. (b) Those which are not able to spread over the insect and do not penetrate the tracheæ.

(2) Contact insecticides which are either soluble in ether or chloroform or are fat solvents are able to spread over the insect and enter the tracheæ.

(3) The rate of spread of these insecticides is governed by their viscosity and cohesion.

(4) Compounds with a viscosity as high or higher than castor oil spread so slowly that in general they may be classed as poor insecticides.

(5) Compounds more volatile than xylene evaporate too quickly for effective work.

(6) Sprays in the form of emulsions may enter the tracheæ as such, or the oil remaining after the emulsion is broken down may spread over the insect and enter the spiracles.

(7) Relatively nonvolatile oils penetrate the body of the insect directly through the walls of the tracheæ as liquids, the rate depending upon the viscosity.

(8) Volatile oils may penetrate the walls of the tracheæ in either vapor or liquid form.

(9) Sprays which are unable to enter the tracheæ in liquid form may penetrate and pass through the tracheal walls as vapor.

(10) Fumigants gain entrance and pass through the tracheal walls in vapor form.

(11) Slightly volatile compounds tend to condense upon the tracheal walls, owing to the fact that small quantities are sufficient to saturate the atmosphere. Owing to this high saturation, these condensations tend to penetrate the chitin rather than to re-evaporate. Volatility is an index of the ability of the compound to gain entrance into the insect and is therefore closely correlated with toxicity.

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The Persian Oilfields

In an admirable lecture, entitled "The Romance of Petroleum," delivered at the Royal Institution, Sir Boverton Redwood, after discussing the approaching exhaustion of the American supplies of oil, said: "Under these conditions the British Government is to be congratulated on having secured the control of the exceptionally prolific oilfields of Persia. The circumstances in which this important acquisition, which is entitled to rank with Disraeli's purchase of the Suez Canal shares, was rendered possible are worthy of being recorded. Fighteen years ago, the late Mr. W. Knox D'Arcy obtained from the Persian Government a concession for the explcitation of petroleum over the whole of Persia, with the exception of the portion bordering on the Caspian Sea. Successful drilling operations were carried out at Kasr-i-Shirin, on the Turco-Persian frontier, and later the work of development was concentrated in an area about 150 miles from the port of Mohammerah, on the Persian Gulf. The results obtained exceeded the most sanguine anticipations, but the financial burden had become very great, pioneer work of this description in such a country being exceptionally costly, and if Mr. D'Arcy had subordinated his patriotism to his self-interest the concession would have been lost to this country, for at this juncture he received tempting offers from continental financiers, who were fully alive to the vast importance of it. Supported by Lord Fisher, Mr. Pretyman, the late Sir Gordon Miller and Sir Frederick Black, Mr. D'Arcy declined to entertain in any form the seductive proposals made to him, being determined that at whatever cost to himself the Persian oilfields should remain under British control, and in 1909, with the powerful cooperation of the Burmah Oil Company and the late Lord Strathcona, the Anglo-Persian Oil Company was formed, with a working capital of £1,200,000. During the succeeding four years the company carried out a comprehensive scheme of development, under the able guidance of Mr. Charles Greenway, and with the help, up to the time of his death, of Mr. C. W. Wallace. Drilling was actively continued, a pipe-line was laid from the oilfields to Abadan, on the Persian Gulf, where a refinery was erected, and a large amount of geological exploratory work was done. All this involved a large outlay of capital, and as the company's cash resources were becoming exhausted there was again a risk of the introduction of foreign control. At this juncture Mr. Greenway was fortunate, with the help of Sir Francis Hopwood (now Lord Southborough), in inducing Mr. Winston Churchill, then First Lord of the Admiralty, to give his personal attention to the position and prospects of the company, with the result that the British Government purchased a controlling interest in the undertaking for the sum of £2,200,000, and nominated two directors, Lord Inchcape and Admiral Slade, to serve on the Board. This action was taken in the face of considerable opposition, both in the House of Commons and outside, and statements were freely made that the Government had made a disastrous bargain, but at the last annual general meeting of the company, Mr. Greenway had the gratification of being able to announce that the profits had already become so large that if the Government wished to dispose of their holding he was prepared to find purchasers for it for not less than six million pounds sterling, and, perhaps, eight million. Of the vast area of presumably oil-bearing territory which the company controls only a small part has been brought into active development, but this has proved to be remarkably rich, one of the wells being reported at the meeting to have so far yielded about 1,750,000 tons of oil, and to be still producing as freely as ever, with practically no diminution in the gas-pressure governing the flow."—*The Engineer.*

Soy-Bean Varieties

The soy bean is native of southeastern Asia and has been cultivated as a food crop by the Chinese for more than 5,000 years. In extent of uses and value it is the most important legume grown in Asiatic countries. The plant is found growing in its wild form in southern China and on the southern islands of Japan.

The number of varieties cultivated in the Orient is very extensive and during the past ten years the Department of Agriculture has brought in through the Office of Foreign Seed and Plant Introduction nearly 1,000 introductions, nearly all of which were distinct sorts. Very seldom is the same sort received twice unless from the same locality. In China and Japan the varieties are distinguished by color, shape, size and use of the seed, and, to a slight extent, by the maturity. Certain sorts are favored for making bean cheese, others for bean sprouts, some for soy sauce, and still others for the production of oil and meal. In America, varieties are classified according to color, size, and shape of seed, maturity and habit of plant, and color of pubescence and flowers. Analyses made of all varieties introduced thus far show a range of from 12 to 24 per cent oil and from 30 to 46 per cent protein. The Department of Agriculture is doing considerable work in the selection of high oil-bearing varieties and also those with a high percentage of protein for food purposes. Investigations as to starch content indicate varieties having a total absence of starch to a few having perhaps about 3 per cent. In most varieties examined, the starch is found around the hilum, while in one instance a small quantity was found scattered throughout the cotyledons.

In Oriental countries the soy bean is utilized largely for food, being elaborated into a great variety of productions such as soy sauce, vegetable cheeses (fresh, dried, fermented, and smoked), vegetable milk, and bean sprouts. All of these products are rich in protein and furnish, with rice, a well-balanced diet to the people of these countries. In Europe and America soy-bean flour or meal has been used to a small extent for many years as a special food for persons requiring a food of low starch diet. During the last two or three years the dry beans are assuming a place on the American market and are used the same as the field or navy bean. The green beans, about three-quarters to full grown, are finding favor as a green vegetable, being utilized like the lima or butter bean.

As an oil seed, the soy bean has taken an important place in the world's commerce and has become an important competitor of other vegetable oils. Hundreds of thousands of tons of beans are being crushed for oil and meal in Asia, America, and European countries. The oil is used quite extensively in the manufacture of food stuffs such as butter and lard substitutes.

The soy bean, with its products, oil and meal, present great possibilities in supplementing our ordinary food products during the present emergency, and once introduced on the market will give a highly nutritious food at very low cost. Extensive areas in the United States are suited to the production of soy beans. Although the acreage of the crop the past season is about five times that of five years ago, it should, and no doubt will, assume an important place among the farm crops of the United States.—W. J. Morse before the Botanical Society of Washington.

The Preservation of Negatives

While most photographers pay every due regard in the way of fixing and washing to the reasonable permanence of negatives it is doubtful if many give adequate consideration to the conditions under which a negative may be depended upon to keep in good physical condition for a long period. We are speaking now not of permanence of the image on the emulsion film, but of that of the film itself in the way of retaining its strength and adherence to the glass support. No doubt in the case of many negatives this is a thing which is not of much account, since defects of this kind manifest themselves only after a good few years. But where the utmost permanence of the negative in every respect is a matter of importance it is as well to remember that the most favorable conditions in which to achieve this end are the use of nothing but a plain hypo bath (and water for washing it out), after development. In particular the use of a separate alum bath is at any rate a contributory cause to the disintegration of the gelatine film after a term of years; and we would even regard with some suspicion fixing hardening baths into the composition of which alum enters. We mention this point because the other day a photographer suggested to us, apparently with no idea that there was anything harmful in it, the soaking of negatives in a weak bath of hydrochloric acid, followed by a brief rinse before drying them. Only time could show whether such a process as this (adapted for removing stains), would have a deleterious effect on the negatives, but it certainly is open to suspicion.—*Brit. Jour. of Photog.*

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Table of Contents

PAGE

Modern Aeronautics—I.—By Dr. W. F. Durand 130
Origin of the Nonius 131
The Aurora.—By Otto Stuhlmann, Jr.—6 illustrations 132
The Psychology of Color—II.—By Leonard Thompson Troland 134
Factors Influencing the Spread of Parasites 135
Ancient Methods for Stripping Films 135
Imports of Palm Oil 135
Waterproofing Compositions 135
National Economy in England.—5 illustrations 136
The Ornithopter.—By Herbert Chatley 136
Use of Chromic Acid and Hydrogen Peroxide as an Etching Agent 136
How Can Soft Coal Be Burned Without Smoke in Marine Boilers? 137
Valonia Tanning Material 137
Substitutes for Wheat 138
Science Applied to War 138
Position-Light Signals for Railroad Service.—By A. H. Rudd 139
Printing Ink for Half-Tone Work 139
The Use of Soap Films.—By A. A. Griffith and G. I. Taylor.—2 cuts 140
On Severe Winters 141
Correspondence—Use of the Heliograph—Gravitation 141
Contact Insecticides.—By William Moore and S. A. Graham 142
The Persian Oilfields 144
Soy-Bean Varieties 144
The Preservation of Negatives 144

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Co.,
citors,
oadway,
ork, N. Y.

PAGE
..... 130
..... 131
..... 133
on Tro-
..... 134
..... 135
..... 135
..... 135
..... 135
..... 136
..... 136
Etching
..... 136
Marine
..... 137
..... 137
..... 138
..... 138
Rudd. 139
..... 139
ylor.—
..... 140
..... 141
..... 141
raham. 142
..... 144
..... 144
..... 146